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Lloyd's Register of Shipping.

RULES FOR ELECTRIC PROPELLING MACHINERY

AND

RULES FOR ELECTRICAL EQUIPMENT.

INDEX.

RULES FOR ELECTRIC PROPELLING MACHINERY.

(For Tables, see pages 85-94).

GENERAL.

Section 1. In vessels propelled by electrical machinery, either wholly or partly by this means, the Rules with regard to machinery are the same as those relating to steam engines so far as regards the testing of material used in their construction and fitting of sea connections, suction and discharge pipes, shafting, stern tubes and propellers.

The following rules are also to be observed. These relate to the electric propulsion equipment, with such references to the mechanical equipment as are required for the successful operation of the combined system. Such requirements are additional to those detailed in the appropriate sections of the Rules.

CONSTRUCTION.

Section 2. 1. In vessels built under special survey and fitted with electric propelling machinery, the whole of the electrical machinery, including switch gear, control gear, cables, main and auxiliary generators, motors and exciters, are to be constructed under special survey.

Any alterations and additions to the installation which are made are to be carried out under the inspection, and to the satisfaction, of the Surveyors.

2. In the cases of electric propelling machinery or engines being built under special survey, the distinguishing mark ✠ will be noted in red, thus :—✠LMC or ✠NE.

3. In order to facilitate the inspection, the plans of the machinery, control gear, cables and electric circuits are to be submitted for approval.

4. The Surveyors are to examine the materials and workmanship from the commencement of the work until the final test of the machinery under full power working conditions has been satisfactorily carried out. Any defects are to be pointed out as early as possible.

5. Any novelty in the construction, operation or application of the machinery is to be reported to the Committee and submitted for approval.

STEAM ENGINES FOR PROPULSION GENERATORS.

Section 3. 1. **Governing.**—An efficient governor is to be incorporated, which is to be arranged so that when operating at rated speed and the rated load is thrown off, the maximum variation in speed is not to be sufficient to bring the emergency governor into operation, and the permanent variation is not to exceed four per cent of the rated speed.

NOTE :—Exhaust steam turbines working in conjunction with reciprocating engines require an emergency overspeed governor only.

2. **Speed Control.**—When the propeller speed is arranged to be varied by controlling the engine speed the control is to be arranged to permit increments and decrements of speed not exceeding one per cent of maximum speed between 50 per cent and 100 per cent of maximum rated speed.

3. **Maximum Speed.**—The engines are to be capable of withstanding for five minutes without injury a speed of 15 per cent in excess of the maximum rated speed.

4. **Emergency Governor.**—An emergency overspeed governor, independent of the main governor, is to be arranged to trip the throttle valve when the speed exceeds the rated maximum running speed by not less than 10 nor more than 15 per cent. It is also to be arranged for hand tripping.

5. **Mixed Pressure Turbines.**—If, in the case of a turbine, exhaust steam can be admitted to the lower stages, an automatic shut-off controlled by the governor and emergency trip is also to be provided.

6. **Bled Steam.**—When provision is made for bleeding steam from the intermediate stages of a turbine, non-return valves, or positive shut off valves operated through oil pressure by the emergency governor, are to be fitted.

7. **Torque Limiting.**—In cases where the arrangements permit a propelling motor to be connected to generating plant having a continuous capacity higher than the motor rating, means are to be provided to limit the continuous input to the motor to approximately five per cent above the torque for which the shaft is approved.

8. **Lubricating Oil.**—Steam turbine driven sets are to be provided with a suitable emergency supply of lubricating oil as required by **Section 9** of the **Rules for Steam Engines** and are to have in addition a gravity tank having sufficient reserve to maintain lubrication until the unloaded turbine comes to rest from its maximum rated running speed.

9. **Mechanical Balance.**—The engines and generators are to be so constructed, erected and supported that when running at any and every working speed all revolving and reciprocating parts are well balanced so as not to give rise to any appreciable vibration.

OIL ENGINES FOR PROPULSION GENERATORS.

Section 4. 1. **Governing.**—An efficient governor capable of rapidly shutting off the flow of oil fuel is to be provided. It is to keep the engine speed within seven per cent momentarily and three and a-half per cent permanently at full speed when full load is removed.

2. **Emergency Governor.** — A suitable overspeed emergency governor, independent of the main governor, is to

be arranged to cut off the fuel from the cylinders when the speed exceeds the rated maximum running speed by approximately 20 per cent.

3. **Critical Speed.**—When coupled to the generator or generators the combined set must not run within the vicinity of a critical at any designed running speed.

4. **Rating.**—The engine is to be capable, for periods of one hour, of developing a load 10 per cent above its rated output within the limits of variation in speed defined in **clause 1** without undue heating of the engine or other mechanical trouble. The rated output in B.H.P. (unless otherwise approved) is to be the load required to drive the generators and all direct coupled auxiliaries at their continuous maximum rating for a period of 12 hours when working with a barometric pressure of 30 inches of mercury and a surrounding air temperature of 62° F. (16·7° C.).

GENERAL REQUIREMENTS OF ELECTRIC PROPULSION MACHINES.

Section 5. 1. **Insulation.**—(*a*) All windings are to be insulated and treated to resist moisture, sea air and oil vapour.

(*b*) All windings are to be insulated from the frame with mica or micanite. Where it is desired to use other types of insulation, particulars regarding the behaviour, properties and life of the materials are to be submitted for consideration.

2. **Terminals.**—The terminals are to be so secured and spaced or shielded that they cannot be accidentally earthed, short circuited or touched. Cable conductors are to be furnished with appropriate sweating sockets.

3. **Coolers.**—If water coolers are employed they are to be arranged so as to prevent leakage or condensation from cooler tubes from entering the machines.

4. **Thermometers.**—Machines having an enclosed ventilating system or ducts for the exhaust air are to be fitted with thermometers for recording the temperature of the ventilating air as it leaves the machine.

5. **Ventilation.**—Ample provision is to be made for supplying cool air to and removing hot air from the machine and to avoid as far as practicable any intake of moist or oil-laden atmosphere.

Where the machines are not ventilated by a closed system, using water coolers, they are to be ventilated with cooling air not exceeding 120° F. (49° C.). In cases where the ventilating air exceeds 120° F. the permissible temperature rise of the machine is to be reduced by an amount equal to the excess temperature.

6. **Heating when Idle.**—All generators of 500 kw. or motors of 500 S.H.P. and over, are to be provided with efficient means for heating the windings, either electrically or otherwise, to prevent condensation when idle. If steam pipes are used for this purpose, the joints are not to be within the machine.

7. **Shaft Currents.**—Means are to be provided to prevent circulating currents passing from the journals to the bearings.

8. **Excitation.**—(*a*) Systems dependent on the auxiliary generators for excitation are to be capable of manœuvring and of maintaining power at all times with a fall of 10 per cent of excitation voltage at the bus-bars.

(*b*) For large equipments it is recommended that an alternative means of excitation should be provided. The auxiliary generators may constitute this reserve.

9. **Facilities for Inspection and Repair.**—For the purposes of inspection and repair, provision is to be made for the withdrawal and replacement of the field coils of direct

current machines and salient pole alternating current machines, and for sufficient access to stator and armature coils. Facilities are to be provided for supporting the motor shaft to permit the withdrawal and inspection of bearing bushes. Wear-down gauges are to be supplied for generators of 1,000 kw., and motors of 1,000 S.H.P., and over.

10. **Mechanical Protection.**—Suitable handrails or screens are to be provided to prevent personal injury or the entrance of extraneous bodies. All live parts in excess of 250 volts to earth, are to be suitably guarded or enclosed. Machines are to be amply protected against drip and mechanical damage.

11. **Lubrication.**—(*a*) Means of lubrication are to be efficient at all running speeds and all normal working oil temperatures, and with the ship inclined from the normal at any angle up to 15° transversely and 10° longitudinally, and with rolling up to 22½° without the spilling of oil.

(*b*) Oil flingers or other suitable means are to be provided to prevent the lubricant from creeping along the shaft or otherwise gaining access to the insulation of the machine or any live part thereof.

12. **Position in Ship.**—(*a*) The machines are to be placed in well-ventilated compartments in which inflammable gases cannot accumulate, and in such a position as to be clear of all inflammable material. Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above the machines.

(*b*) The machines are to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam or oil, and in all vessels engaged on open sea service they are preferably to be placed with their axes of rotation in a fore and aft direction. If placed

athwartships end play is to be reduced to a minimum and provision made for the end thrust due to rolling of the vessel.

(*c*) Ventilation ducts are to be so arranged that water or extraneous bodies cannot drop into the machines.

13. **Foundations and Bilges.**—(*a*) Plans of the seatings for the main propulsion generators and motors, are to be submitted for approval.

(*b*) Special means are to be provided to prevent the accumulation of bilge water under the machines and a direct bilge suction should be fitted in the main motor room. It is recommended that permanent means of illumination of the bilges under the machines be provided.

14. **Manœuvring.**—The torque available for manœuvring is to be reasonably in excess of the trailing action of the propeller to enable the latter to be stopped or reversed in a reasonable time when the vessel is travelling at maximum service speed.

ALTERNATING CURRENT SYSTEMS.

Section 6. 1. **Limiting Pressures.**—The pressure, under normal working conditions, at any part of the system for equipments not exceeding 15,000 S.H.P. per shaft is not to exceed the following values.

Between lines	...	3,500 volts.
To earth ...	...	2,020 volts.

Proposals involving higher voltages for larger equipments are to be submitted for consideration.

2. **Stator Laminations.**—(*a*) Laminations are to be securely clamped, and are to be efficiently and permanently supported around the whole of the periphery.

(*b*) Laminations are to be suitably insulated from one another with an approved durable material.

3. **Propulsion Generators.**—(*a*) The ratings and limits of permissible temperature rise for alternators are to conform to Appendix 3. If the ventilating air exceeds 120° F. (49° C.) the permissible temperature rise is to be reduced by an amount equal to the excess temperature.

(*b*) Machines of 5,000 k.v.a. and over, or machines having an axial core length of one metre or over, are to have at least three embedded temperature detectors and a temperature indicating instrument. Detectors of this type should be fitted to smaller machines where practicable.

(*c*) Suitable space is to be provided for the removal of the rotor for the inspection of the rotor and stator.

(*d*) Stator and rotor windings are to be suitable for manœuvring in accordance with **clause 6** (*b*) of this Section without impairment.

4. **Propulsion Motors.**—(*a*) The ratings and limits of permissible temperature rise for motors are to conform to Appendix 3.

(*b*) The collector rings and rotor terminals of synchronous type motors are to be suitably insulated for the voltage induced during manœuvring. Insulating barriers are to be provided where necessary.

(*c*) Induction rotor windings of synchronous type motors, used for manœuvring purposes, are to be mechanically strong and of ample section to prevent over-heating during repeated manœuvres in accordance with **clause 6** (*b*) of this Section.

(*d*) Provision is to be made for machining the collector rings or for their easy removal for that purpose.

(*e*) Machines of 5,000 S.H.P. and over, or machines having an axial core length of one metre or over, are to have at least three embedded temperature detectors and a temperature indicating instrument. Detectors of this type should be fitted to smaller machines where practicable.

5. **Stability.**—The motors and generators are to be designed and arranged to maintain electrical stability and to remain in step under all normal conditions of running.

6. **Excitation.**—(*a*) Exciters, balancers, boosters and motors for driving them are to conform to Appendix 4, except that in tropical climates or where fixed in hot situations where the ventilating air adjacent to the machine exceeds 120° F. (49° C.), the temperature rise at rated full load is not to exceed 63° F. (35° C.) all temperatures being measured by thermometer.

(*b*) After a full load run of the complete equipment, for not less than three hours, followed by a full speed reversal and five normal manœuvres within a period of 30 minutes, the temperature rise of any machine supplying the extra excitation required for alternating current systems, is not to exceed that permitted in the preceding clause by 18° F. (10° C.).

(*c*) Field windings and all machines supplying over-excitation during manœuvring are to be capable of withstanding the excess current over a reasonable period, to allow for inadvertent delay during a reversal operation, without impairment, after attaining the temperature rise corresponding to normal continuous working.

(*d*) Negative boosters are, when necessary, to be provided with overspeed protection.

(*e*) The strength of shafts and couplings of exciting machines for alternating current equipments is to be suitable for the increased output necessary during manœuvring.

DIRECT CURRENT SYSTEMS.

Section 7. 1. **Limiting Pressures.**—For equipments not exceeding 15,000 S.H.P. per shaft the pressure to earth at any part of the system under normal working conditions is not to exceed 600 volts. The voltage of any single armature is not to exceed 1,000.

Proposals involving higher voltages for larger equipments are to be submitted for consideration.

2. **Propulsion Generators and Motors.**—The ratings and limits of permissible temperature rise are to conform to Appendix 3.

3. **Brush Gear.**—The brushes are to be staggered longitudinally to prevent the formation of ridges on the commutators and arranged in such manner that in multipolar machines every part of the commutator working surface is swept by an equal number of positive and negative brushes.

4. **Excitation.**—The arrangements for motor and generator excitation are to be such that if the motor excitation circuit is opened by a switch or contactor the generator excitation is simultaneously opened or the generator voltage is immediately reduced to zero.

5. **Overspeed Protection.** — Overspeed protection devices are to be arranged to interrupt the supply of power, and the armatures are to be suitably constructed to prevent damage due to temporary overspeeding, where the system permits excessive overspeeding at light loads.

GENERAL REQUIREMENTS FOR PROPULSION CONTROL GEAR AND SWITCHBOARDS.

Section 8. 1. **Position.**—(*a*) Control boards and switchboards are to be placed in accessible, well-ventilated positions, free from inflammable gases and acid fumes, and in which they are not exposed to risk of mechanical injury or damage from water, steam or oil.

(*b*) Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches of any live metal, measured horizontally from, or four feet measured vertically above, the panel.

(*c*) Essential controls for manœuvring operations are to be grouped at the starting platform and any necessary instruments and gauges are to be in direct view from this position.

2. **General Construction.**—(*a*) Switchboards and control panels are to be constructed wholly of durable, non-ignitable, non-absorbent materials.

(*b*) If insulating material be used for the base, it is to be of permanently high dielectric strength and insulation resistance, and full particulars regarding its properties should be submitted for consideration.

(*c*) If semi-insulating materials such as marble or slate are used, all conducting parts are to be insulated from the slate or marble slab with mica or other approved non-hygroscopic insulating material, and the slab is to be similarly insulated as a whole from the frame on which it is mounted; the frame is to be effectually earthed.

(*d*) The various live parts are to be so arranged, by suitable spacing or shielding with non-ignitable insulating materials, that an arc cannot be maintained between any such parts.

(*e*) All parts, including connections, are to be readily accessible from the front or back. Fuses are to be placed in approved positions.

(*f*) Omnibus bars and ordinary bare connecting conductors on switchboards are to be proportioned so that their average temperature will not rise more than 54° F. (30° C.) above that of the surrounding air when rated at 2,000 amperes or below when the maximum current flows through them continuously. For bare conductors rated above 2,000 amperes the temperature rise is not to exceed 72° F. (40° C.). The temperature rise of each part is not to exceed the average temperature by more than 9° F. (5° C.) and in other respects they are to comply with Appendix 1.

(*g*) All cable connections in the control and switchgear in any circuit essential for manœuvring or maintenance of propelling power are to be stranded and to consist of not less than seven strands and have a sectional area of not less than ·0045 square inches (7/·029).

(*h*) All nuts and screws securing electrical connections are to be effectively locked so that they cannot become loose.

(*i*) All circuits, instruments and important apparatus are to be clearly and indelibly labelled for indentification. If detachable name plates are employed, they are to be non-ignitable, and if of metal are to be disposed so as not to involve risk of short circuits or earths.

(*j*) Each voltmeter, pilot or earth lamp with its connecting wires is to be protected individually by a fuse on each insulated pole close to the incoming supply. Pilot lamps and indicating lamps may have common fuses.

(*k*) Switches and contactors are as far as practicable to be connected so that their blades or moving parts are not alive in the "off" or de-energised position.

(*l*) Where switches and fuses are fitted on the same pole they are to be arranged so that the fuses are not alive when the corresponding switches are in the "off" position.

(*m*) Switches and circuit breakers are to conform to the **Rules for Electrical Equipment, Section 3, clause 5.**

(*n*) Fusible cut-outs are to comply with the **Rules for Electrical Equipment, Section 3, clause 6,** and are to be suitably labelled with the circuits or devices which they control.

(*o*) All levers, handles, handwheels, interlocks, and their connecting links, shafts and bearings for the operation of switches and contactors are to be of such proportions that they cannot be broken by manual operation.

(*p*) Suitable interlocks, preferably mechanical, are to be provided to prevent damage by improper operation, such as the opening of switches or contactors not intended to be operated while carrying current.

(*q*) Provision is to be made for the manual operation of all manœuvring contactors, switches, field regulators, or controllers with reasonable effort, without the aid of solenoids or other electric, pneumatic or hydraulic aid. If such aid be used for normal operation, failure of the electric, pneumatic or hydraulic aid must not result in interruption of power to the screw shaft and the device must be capable of purely manual operation without any delay in changing over to manual control.

NOTE:—This requirement does not apply to bridge control.

(*r*) The cases of all instruments using a higher pressure than 250 volts to earth, and secondary windings of instrument transformers, are to be earthed.

(*s*) Switches normally subject to arcing, such as the short circuiting and isolating switches for direct current generators connected in series, are to be provided with substantial and renewable arcing tips.

(*t*) All apparatus is to be arranged to function satisfactorily under conditions of vibration and shock, and with the ship inclined from the normal at any angle up to 15° transversely and 10° longitudinally, and when rolling up to $22\frac{1}{2}$° from the vertical.

(*u*) All devices dependent on current supplied from the auxiliary bus-bars are to be arranged to operate satisfactorily with a voltage variation from minus 10 per cent to plus 5 per cent.

(*v*) For the purpose of maintaining alignment and ease of operation, operating shafts are to be fitted with flexible

(*g*) All cable connections in the control and switchgear in any circuit essential for manœuvring or maintenance of propelling power are to be stranded and to consist of not less than seven strands and have a sectional area of not less than ·0045 square inches (7/·029).

(*h*) All nuts and screws securing electrical connections are to be effectively locked so that they cannot become loose.

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(*j*) Each voltmeter, pilot or earth lamp with its connecting wires is to be protected individually by a fuse on each insulated pole close to the incoming supply. Pilot lamps and indicating lamps may have common fuses.

(*k*) Switches and contactors are as far as practicable to be connected so that their blades or moving parts are not alive in the "off" or de-energised position.

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(*o*) All levers, handles, handwheels, interlocks, and their connecting links, shafts and bearings for the operation of switches and contactors are to be of such proportions that they cannot be broken by manual operation.

(*p*) Suitable interlocks, preferably mechanical, are to be provided to prevent damage by improper operation, such as the opening of switches or contactors not intended to be operated while carrying current.

(*q*) Provision is to be made for the manual operation of all manœuvring contactors, switches, field regulators, or controllers with reasonable effort, without the aid of solenoids or other electric, pneumatic or hydraulic aid. If such aid be used for normal operation, failure of the electric, pneumatic or hydraulic aid must not result in interruption of power to the screw shaft and the device must be capable of purely manual operation without any delay in changing over to manual control.

NOTE:—This requirement does not apply to bridge control.

(*r*) The cases of all instruments using a higher pressure than 250 volts to earth, and secondary windings of instrument transformers, are to be earthed.

(*s*) Switches normally subject to arcing, such as the short circuiting and isolating switches for direct current generators connected in series, are to be provided with substantial and renewable arcing tips.

(*t*) All apparatus is to be arranged to function satisfactorily under conditions of vibration and shock, and with the ship inclined from the normal at any angle up to 15° transversely and 10° longitudinally, and when rolling up to $22\frac{1}{2}$° from the vertical.

(*u*) All devices dependent on current supplied from the auxiliary bus-bars are to be arranged to operate satisfactorily with a voltage variation from minus 10 per cent to plus 5 per cent.

(*v*) For the purpose of maintaining alignment and ease of operation, operating shafts are to be fitted with flexible

couplings and expansion joints where necessary and means are to be provided for effective lubrication.

(*w*) All steel parts are to be suitably treated to resist corrosion.

3. **Overload and Short Circuit Protection.**—Provision is to be made for protection against severe overloads or electrical faults likely to result in serious injury to the plant, but the operating point is to be set sufficiently above the currents and loads usually experienced in a heavy sea-way or when manœuvring, to prevent interruption of power.

4. **Earth Detection.**—(*a*) The main propelling circuit is to be provided with means for detecting earth faults.

(*b*) For D.C. equipments exceeding 500 volts and for all A.C. equipments, aural and visual alarms are to be operated, but power supply is not to be interrupted on the occurrence of a fault, so that the plant may continue to operate with a single earth. If an earth connection be used for the operation of the detector, the arrangements are to be such that the earth circuit is automatically opened in order to stop the circulation of fault current.

(*c*) Earth detection devices are to be arranged to function for all earth leakage faults exceeding five amperes. On three-phase alternating current systems at least 95 per cent of the generator and motor windings are to be protected.

(*d*) A switch may be installed to cut out the aural device to prevent continuous alarm, but in such case the visual device is to be automatically switched on when the aural device is switched off.

(*e*) Excitation circuits are to be provided with lamps, voltmeters or other suitable means to indicate continuously the state of the insulation of the system under running conditions.

5. **Mechanical Protection.**—All exposed current carrying parts having a potential of over 250 volts to earth are to conform to the following requirements :—

(*a*) Terminals are to be enclosed.

(*b*) The sides and rear of switchboards and control panels are to be suitably screened.

(*c*) Access doors are to have prominent and permanent nameplates giving the maximum voltage, and are to be interlocked to prevent access while such parts are alive, or in approved cases are to be provided with a special key under the care of the chief engineer.

(*d*) Exposed current carrying parts exceeding 250 volts to earth are not to be permitted on any switchboard or control panel.

6. **Bridge or Deck Control.**—(*a*) The control is to be simple and easy to operate.

(*b*) It is to be such that the operator cannot produce currents or loads in excess of the working capacity for which the plant is designed.

(*c*) Control is to be carried out without reference to electrical instruments.

(*d*) Alternative control in the engine room is to be provided, and so arranged that transfer of control to the engine room can be made in emergency without excessive loss of time.

(*e*) It is to be arranged so that simultaneous control of the propelling machinery from the bridge and engine room is not possible.

7. **Instruments and Gauges.**—(*a*) Instruments and gauges which are necessary for the efficient operation of the plant are to be provided. Particulars are to be submitted for

consideration. In cases where the rotation of the propeller motors cannot readily be observed from the starting platform, indicators are to be provided.

(*b*) All essential instruments are to be capable of withstanding vibration and shock without impairment and are to be fitted in moisture-proof cases.

(*c*) Instruments are where necessary to be protected from the influence of stray magnetic fields.

(*d*) A 500-volt insulation tester, giving the resistance in megohms, for the purpose of testing and tracing faults is to be carried on all sea-going vessels.

8. **Discharge Protection.**—(*a*) For the protection of the field windings and cables efficient means are to be provided for limiting the induced voltage when the field circuits are opened.

(*b*) Where excitation is obtained from the auxiliary bus-bars efficient means are to be provided to limit the induced voltage on the bus-bars when the generator or distribution circuit breaker opens.

9. **Direct-current Systems.**—(*a*) Where two or more direct-current generators are connected in series, means are to be provided to prevent the reversal of the prime mover on the failure of the power supply to any one generator if such reversal would result in damage or overspeeding.

(*b*) If the regenerated energy transmitted by the propeller motor on stopping or reversing the propeller is of a magnitude that would cause an undue increase in the engine speed, means are to be provided for suitably absorbing or limiting such power.

(*c*) Where the propulsion generators are also to be used for other purposes, suitable overload protection and provision for voltage adjustment is to be made in conformity with the **Rules for Electrical Equipment.**

10. **Reversing Switches.**—(*a*) Contactors or switches used for reversing the rotation of the propeller, are to be mechanically interlocked to prevent the circuits for ahead and astern rotation being closed simultaneously.

(*b*) The reversing contactors or switches are also to be provided with means for forcing them open if they should become stuck in the closed position.

11. **Resistances.**—(*a*) Resistances are to comply with **Section 12, clause 2,** of the **Rules for Electrical Equipment.**

(*b*) Shunt resistances connected across the field circuit of synchronous propelling motors when they are functioning as induction motors are to be suitably insulated for the voltage induced when reversing and amply rated to allow for inadvertent delay during the reversing operation.

12. **Temperature Alarm.**—Machines having an enclosed ventilating system or ducts for the exhaust air, are to have an aural alarm device arranged to operate when the outgoing air exceeds the predetermined safe value.

13. **Reversing Levers and Handwheels.**—Propeller reversing levers or handwheels are to be clearly and permanently marked with the positions for "ahead" and "astern" working. Levers or handwheels placed athwartships are to be arranged for right hand or clockwise rotation for ahead working or if operated in a fore and aft direction to be arranged to correspond with the direction in which the vessel is moving.

14. **Auxiliary Power.**—Distribution circuits connected to the auxiliary bus-bars for excitation and lubricating oil pumps, etc., are to be suitably protected from interruption due to overloading of non-essential circuits.

15. **Speed Control.**—When the propeller speed is arranged to be varied by voltage control or similar electrical

means, the control is to be arranged to permit an adjustment between 50 per cent and 100 per cent of maximum rated speed in steps not exceeding one per cent of the maximum speed.

CONDUCTORS AND CABLES.

Section 9. 1. **Conductors.**—(*a*) All conductors are to be of annealed copper conforming to the Standards of the International Electrotechnical Commission Publication No. 28.

(*b*) Where the insulating covering of the conductor contains sulphur, each wire is to be efficiently and uniformly coated with tin free from all impurities.

(*c*) Conductors in any circuit essential for manœuvring or maintenance of propelling power are to be stranded and to consist of not less than seven strands and to have a sectional area not less than ·0045 square inches (7/·029).

(*d*) The size of conductor is to be selected so that the drop in voltage, when carrying rated full load and overloads, is not greater than that allowed for in the design of the machines.

(*e*) The current in any conductor is not to exceed that given in **Table I.** when carrying current continuously or **Table III.** when intermittently loaded. In no case is a shorter rating than one half-hour to be taken. In the case of field discharge circuits, particulars should be submitted for consideration.

(*f*) Where multicore cables are used the sizes are to be submitted for approval.

(*g*) Bus-bars and connections are to be in accordance with Appendix 1 and, if used for connections to machines, must be rigidly and strongly supported, efficiently insulated and guarded, and protected from drip and jets of liquid or steam. Pipes are not to enter ducts containing such connections. Suitable means are to be arranged for draining any accumulation of moisture in ducts.

2. **Insulation and Protective Covering of Cables.**—(*a*) All cables are to conform to **Section 5** of the **Rules for Electrical Equipment.**

(*b*) For multicore cables the thickness of dielectric on each conductor is to be the same as for the same size of single core cable and the thickness of lead sheathing is to be in accordance with **Tables X., XI., XII.** and **XIII.** The bedding and diameter of wire armouring are to be in accordance with **Table VI.**

(*c*) All cables for pressures exceeding 250 volts to earth are to be lead covered and braided. They are also to be armoured or protected in an approved manner. The thickness of dielectric and lead covering is to conform to **Table V.** and **XII.** (1,000 volt paper or varnished cambric insulated), **Table XI.** (660 volt rubber insulated) or **Table XIII.** (3,300 volt paper or varnished cambric insulated).

A dielectric test is to be applied to all cables in accordance with the **Rules for Electrical Equipment, Section 5, clause 7** (*a*), 3,300 volt cable being tested at 10,000 volts under the conditions laid down therein.

3. **Installing and Fixing of Cables.**—(*a*) All cables are to be installed and fixed in conformity with **Section 6** of the **Rules for Electrical Equipment.**

(*b*) Cables are to be run in accessible, well-ventilated positions where they can be easily inspected.

4. **Cables for Alternating Currents.**—(*a*) Single core lead covered cables are to have their lead sheaths bonded together and earthed only at approximately the mid-point of the cable run. The remainder of the run is to be carried on insulators to prevent the circulation of currents in the metal sheaths. The sheaths of multiconductor cables are to be earthed at each end and long runs should also be earthed intermediately.

(*b*) If armoured single core cables are used the armouring is to be of non-magnetic material.

(*c*) Magnetic material is not to be used between single core cables of a group. Where cables pass through bulkheads or steel panels, all the conductors of the same set are to pass through a non-ferrous plate or gland so that no magnetic material passes between the cables, and the clearance between the cables and magnetic material is to be not less than three inches.

NOTE:—This clause does not apply to cables carrying 10 amperes or less.

(*d*) Single core cables carrying 100 amperes or over are to be fixed not less than three inches from parallel magnetic material.

(*e*) Single core cables are to be so arranged that the inductive effects of the group are practically eliminated.

5. **Cable Sockets.**—Large cable sockets are preferably to be secured by two or more studs or bolts, not exceeding $\frac{3}{4}$ inch diameter, and the nuts securely locked.

6. **Synchronous Motor Cables.**—Cables connected to the collector rings of synchronous motors during manœuvring are to be suitable for the voltage induced during those periods.

7. **Interference with Magnetic Compasses.**—Single-conductor circuits carrying continuous current are to be arranged with lead and return conductors fitted as close to one another as possible. Tests are to be made during the adjustment of the compasses to determine the effect of switching the main circuits on and off and careful records are to be kept of any errors observed, whether corrected or not.

SECONDARY BATTERIES.

Section 10. 1. **General.**—All batteries are to conform to **Section 8** of the **Rules for Electrical Equipment.**

2. **Capacity.**—Batteries used for starting main propulsion engines in lieu of compressed air are to comply with the following :—

(*a*) If used for purposes other than starting, full particulars of the battery should be submitted for consideration.

These particulars should include the capacity which it is estimated will be required to give 12 starts in succession of one main engine, also details of the other uses for which the battery is intended; the facilities for charging should also be indicated.

(*b*) If used solely for starting main engines two batteries are to be fitted each capable of starting one main engine six times in succession without recharging. Details of the charging arrangements are to be submitted for consideration.

(*c*) Plans showing the location and arrangement of battery compartment are to be submitted for approval.

TRIALS.

Section 11. 1. **Works Tests.**—(*a*) The machines, switchgear, main cables and control gear, are to be tested in the presence of the Surveyors at the makers' works so far as practicable to ensure compliance with the requirements relating to temperature rise, dielectric strength, insulation resistance and operating characteristics.

(*b*) The dielectric test to be applied to the control gear is to be equal to the test for that part of the machine to which it is to be connected or otherwise is to be 1,000 volts plus twice the rated voltage of the circuit with a minimum of 2,000 volts between poles and between current carrying parts and earth ; the test voltage is to be maintained for one minute.

(*c*) The rotor windings of turbine driven alternators are to be tested for insulation resistance when rotating at maximum rated speed, as well as at standstill.

2. **Ship Trials.**—After installation on board the entire propelling equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction.

The insulation resistance of the main windings of each machine in megohms should be not less than

$$\frac{3 \times \text{rated voltage}}{\text{rated k.v.a.} + 1{,}000}$$

The insulation resistance of cables, field windings and control gear when isolated and separated for testing purposes should be not less than one megohm.

All insulation tests are to be made where possible when the machines are hot and with a D.C. voltage of about 500 applied for sufficient time for the indicator to become practically steady.

SPARE GEAR.

Section 12. Owing to the varied character of equipments an exact list of spares cannot be specified and a list should be submitted for consideration together with or subsequent to the submission of final plans. The following should be included as a minimum for all vessels engaged in open-sea service.

1. **For Generators, Motors and Exciters.**

One set of bearing bushes, with oil rings, if used, of each size and type for the propulsion generators, motor and exciter.

Two lines of brush holders of each size and type.

One set of carbon brushes for one generator, exciter, and one motor.

One shunt field coil of each size and kind used for D.C. generators, exciter and motors.

One set of insulation or insulated brush studs for two lines of brushes of each size and type.

In cases where there is no stand-by exciter or alternative means of excitation, spare armatures for the excitation machines may be required.

One set of slip rings for one motor if of the A.C. type.

2. **Switch and Control Gear.**

One set of contacts liable to burning or wear.

One set of springs.

Ten per cent of each different resistance element, but at least one of each.

One of each type of shunt wound coil used for contactors relays, or trip coils.

Two fuse handles of each type and size, or 10 per cent, but not less than 12 of each type of cartridge or other non-rewireable cut-out.

3. **General.**

Special dismantling tools, if any, required for overhauling machines or control gear.

100 yards of control cable.

A suitable quantity of insulating tape and fuse wire.

4. **Storing.**

Electrical spares should be protected against excessive heat, and against moisture and rodents, and should be periodically tested.

71, Fenchurch Street, London, **E.C.3.**
25th April, 1935.

RULES FOR ELECTRICAL EQUIPMENT.

(For purposes other than Electric Propulsion.)

(*For Tables, see pages 85-94.*)

GENERAL.

Section 1. 1. In cases in which electricity is used on board classed vessels for purposes other than propulsion of the ship, the following Rules are to be observed.

The machines, fittings and cables are to be inspected by the Surveyors.

In order to facilitate inspection, a diagram of the switchboard, also diagrams of the wiring of the installation showing the sizes of the cables, type of dielectric and maximum current in the circuits are to be submitted for approval. The diagrams are to state the insulating material used for the switchboard panels and the materials used for insulating bushes, if any.

Any alterations and additions to the installation which are made are to be carried out under the inspection, and to the satisfaction, of the Surveyors.

2. **Standard Systems.**—The following systems of distribution may be used :—

A. Parallel systems with constant pressure.
   - (*a*) Single wire with hull return.
   - (*b*) Two-wire with direct or single-phase alternating current.
   - (*c*) Three-wire with direct current.
   - (*d*) Three-phase three-wire.
   - (*e*) Three-phase four-wire.

B. Series systems with constant current (direct current only).

3. **Limiting Pressures.**—The pressure of supply is not to exceed the following values :—

A. With direct-current constant-pressure systems :—

(*a*) For power, 500 volts.

(*b*) For lighting and heating, 250 volts.

B. With alternating-current constant-pressure systems :

(*a*) For power and heating, 250 volts.

(*b*) For lighting, 150 volts.

C. With constant-current series systems (direct current only) :—650 volts.

For ships carrying oil having a flash point less than 150° F. (65·5° C.)—*See* Section 15.

GENERATING PLANT.

Section 2. 1. **Rating of Generators.**—Generators are to conform to Appendix No. 2 except that in tropical climates or where fixed in specially hot situations on the ship, the rated full load is not to be exceeded and the temperature rise at rated full load is not to exceed 63° F. (35° C.) on the windings and 72° F. (40° C.) on the commutator, all temperatures being measured by thermometer.

The tests are to be carried out at the makers' works and a certificate giving the results is to be submitted for approval. Machines of 100 kw. and over are to be inspected by the Surveyors during manufacture and testing.

2. **Automatic Regulation of Pressure.**—(*a*) Generators are to be compound wound unless arranged to run in parallel at such distances apart as to render the amount of copper in the equalizing conductors excessive, in which case they may be shunt wound. The series field windings of every compound generator are to be connected to the positive pole of the machine except on single wire systems with hull return, having the negative pole earthed, in which case they are to be connected to the negative pole.

(*b*) Generators, unless otherwise specified, are to be over-compounded 5 per cent under conditions of constant speed and fixed excitation. Alternatively, they may be level

compounded when tested coupled to their prime movers, under conditions of fixed excitation.

3. **Field Regulators.**—Where generators are run in parallel each is to be fitted with an adjustable regulating resistance in series with its shunt field, to vary the pressure of the generator between 5 per cent above, and 10 per cent below the normal at any load, and there are not to be less than 25 equal steps of resistance.

4. **Brush Gear.**—(*a*) The brushes are to be of carbon and are to be provided with flexible copper connections.

(*b*) Means are to be provided for the adjustment of the brushes longitudinally so that they may be staggered to prevent the formation of ridges, in such a manner that in multipolar machines every part of the commutator working surface will be swept by an equal number of positive and negative brushes.

5. **Terminals.**—(*a*) Suitable terminals, clearly marked, are to be provided in an accessible position convenient for wiring, and they are to be furnished with appropriate cable sweating sockets.

(*b*) The terminals are to be so spaced or shielded that they cannot be accidentally earthed, short-circuited, or touched.

6. **Lubrication.**—(*a*) Generators are to be efficiently and continuously lubricated automatically with the base of the machine inclined at any angle up to 15 degrees from the horizontal in any and every direction.

(*b*) If ring lubrication be employed, the rings are to be so constrained that they cannot leave the shaft.

(*c*) Oil flingers or other suitable means are to be provided to prevent the lubricant from creeping along the shaft, or otherwise gaining access to the insulation of the machine or any live part thereof.

(*d*) Each oil lubricated bearing is to be provided with a suitable overflow which, while permitting efficient lubrication when the machine is running, shall prevent excess of oil.

7. **Ventilation.**—Generators are to be so placed that when working they obtain a sufficient supply of cool air, and provision is to be made for removal of the heated air after passing through the machine.

8. **Position in Ship.**—(*a*) The generators are to be placed in a well-ventilated compartment in which inflammable gases cannot accumulate, and in such a position as to be clear of all inflammable material. Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above, the generators.

(*b*) The generators are to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam or oil, and in all sea-going ships they are to be placed with their axes of rotation in a fore and aft direction.

9. **Plant to be Earthed.**—The bedplate and frame of the generating plant are to be efficiently earthed, and insulation is not to be interposed between the prime mover and the generator.

10. **Protection of Connections between Generator and Main Switchboard.**—When a generator is placed in a compartment other than that containing the main switchboard, each such generator is to be provided with a fuse or circuit breaker on each insulated pole, fitted as near as possible to the terminals of the generator. This protection is to be additional to that provided on the main switchboard.

11. **Emergency Trip.**—Where a turbine driven direct current generator is arranged to run in parallel with other generators, a switch is to be fitted on each turbine emergency governor to open the generator circuit breaker when the emergency governor functions.

SWITCHBOARDS.

Section 3. 1. **Position.**—(*a*) Switchboards are to be placed in accessible positions, free from inflammable gases and acid fumes, in which they are not exposed to risk of mechanical injury or to damage from water, steam or oil.

(*b*) Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches of any live metal measured horizontally from, or within 4 feet measured vertically above, the switchboard.

(*c*) Cupboards or compartments containing switchboards must be composed of fire-resisting material or approved lining.

2. **General Construction.**—(*a*) Switchboards are to be constructed wholly of durable, non-ignitable, non-absorbent materials.

(*b*) If insulating material be used for the base, it is to be of permanently high dielectric strength and insulation resistance, and should be submitted for consideration.

NOTE.—In the case of approved synthetic materials, it will be necessary for the manufacturers to demonstrate from time to time that the necessary qualities of the materials supplied by them are being maintained.

(*c*) If semi-insulating materials such as marble or slate are used, all conducting parts are to be insulated from the slate or marble slab with mica or other approved non-hygroscopic insulating material, and the slab is to be similarly insulated as a whole from the frame on which it is mounted; the frame is to be effectually earthed.

(*d*) The various live parts are to be so arranged, by suitable spacing or shielding with non-ignitable insulating materials, that an arc cannot be maintained between any such parts.

(*e*) All parts, including connections, are to be readily accessible from the front or back. Fuses may be placed on a framework behind the switchboard provided they be well clear of busbars, connections, circuit breakers and live parts; that they be easily accessible and a clear and unobstructed gangway of not less than two feet be provided.

(*f*) All nuts and screws securing electrical connections are to be effectively locked, so that they cannot become loose.

(*g*) All omnibus bars and connections on switchboards are to be in accordance with Appendix No. 1.

(*h*) All circuits, instruments and important apparatus are to be clearly and indelibly labelled for identification. If detachable name plates be employed, they are to be non-ignitable, and if of metal are to be so disposed as not to involve risk of causing short circuits or earths.

(*i*) Omnibus bars and ordinary connecting conductors on switchboards are to be so proportioned that their average temperature will not rise more than 54° F. (30° C.) above that of the surrounding air when the maximum current flows through them continuously, and the temperature rise of each part is not to exceed the average temperature by more than 9° F. (5° C.).

(*j*) Every equalizer switch and its connections (including the cable from the generator) is to have a current carrying capacity of not less than 50 per cent of the main current of the generator.

(*k*) Each voltmeter, pilot or earth lamp, with its connecting wires, is to be protected individually by a fuse on each insulated pole.

(*l*) Switches are to be so connected to omnibus bars that their blades or moving parts are not alive in the "off" position.

(*m*) Where switches and fuses are fitted on the same pole, they are to be so arranged that the fuses are not alive when the corresponding switches are in the "off" position.

(*n*) Where single-pole switches or fuse-switches are required by these regulations, they are to be fitted on the same pole throughout the installation.

(*o*) Where a separate fuse and switch or separate fuses and linked switches are required by these regulations, they may be replaced by a fuse-switch or linked fuse-switches, as the case may be.

3. Main Switchgear.—Each main switch-board is to be fitted with the following switchgear as a minimum.

A. Two-wire Systems.

Where only one generator is installed :

(*a*) For the Generator :—

(i) Either a single-pole overload circuit breaker or a single-pole fuse and a single-pole switch on the insulated pole in a single-conductor or a two-conductor earthed system.

(ii) Either a double-pole overload circuit breaker or a fuse on each pole and a double-pole linked switch in a two-conductor insulated system.

(*b*) For each Outgoing Circuit :—

(i) A single-pole fuse and a single-pole switch on the insulated pole in a single-conductor or a two-conductor earthed system.

(ii) A fuse on each pole and a single-pole switch on one pole in a two-conductor insulated system. All these switches are to be on the same pole.

Where more than one generator is installed, the generators not being arranged to run in parallel :

(*c*) For each Generator :—

(i) Either a single-pole overload circuit breaker, or a single-pole fuse and a single-pole switch, on the insulated pole in a single-conductor or a two-conductor earthed system.

(ii) Either a double-pole overload circuit breaker, or a fuse on each pole and a double-pole linked switch in a two-conductor insulated system.

(*d*) For each Outgoing Circuit :—

(i) A single-pole fuse and a single-pole change-over switch on the insulated pole in a single-conductor or a two-conductor earthed system.

(ii) A fuse on each pole and a single-pole change-over switch on one pole, all such change-over switches being on the same pole, in a two-conductor insulated system.

Where more than one generator is installed, the generators being arranged to run in parallel :

(*e*) For each generator, if shunt-wound :—

A circuit breaker with overload and reversed current trips. This circuit breaker to be :—

(i) Single-pole in a single-conductor or a two-conductor earthed system.

(ii) Double-pole in a two-conductor insulated system.

(*f*) For each generator, if compound wound :—

A circuit breaker with overload and reversed-current trips, and a single-pole equalizer switch so interlocked with the circuit breaker that this equalizer switch must be closed before the circuit breaker, and cannot be opened until the main circuit is broken. This circuit breaker to be :—

(i) Single-pole in a single-conductor or a two-conductor earthed system.

(ii) Double-pole in a two-conductor insulated system.

(*g*) For each Outgoing Circuit :—

(i) A single-pole fuse and switch on the insulated pole in a single-conductor or a two-conductor earthed system.

(ii) A fuse on each pole and a single-pole switch on one pole in a two-conductor insulated system. All these switches are to be on the same pole.

B. Three-wire Systems.

Where more than one generator is installed, the generators being arranged to run in parallel, whether the machines are wound for the full pressure or for half pressure and act as balancers :—

(*a*) For each generator, if shunt-wound :—

A double-pole circuit breaker with overload and reversed current trips.

(*b*) For each generator, if compound-wound :—

A double-pole circuit breaker with overload and reversed-current trips, and a single-pole equalizer switch so interlocked with the circuit breaker that this equalizer switch must be closed before the circuit breaker, and cannot be opened until the main circuit is broken.

(*c*) For each outgoing three-wire circuit where the supply is given to three conductors :—

Either a double-pole overload circuit-breaker controlling the outer conductors, or a fuse on each outer conductor and a double-pole linked switch controlling the outer conductors. A fuse or switch is not to be included in the neutral conductor, but this requirement does not preclude the provision of an isolating link for testing purposes.

(*d*) For each outgoing two-conductor insulated circuit where the supply is given from the neutral and one outer of a three-wire system :—

Either a double-pole overload circuit-breaker, or a double-pole linked switch with a fuse on each pole.

(*e*) For each outgoing single-conductor or two-conductor earthed circuit where the supply is given from the neutral and an outer of a three-wire system :—

Either a double-pole circuit breaker with overload trip on that pole which is connected to the outer conductor, or a single-pole fuse on that pole which is connected to the outer conductor and a double-pole linked switch.

C. Three-phase Three-wire Systems.

(*a*) For each generator :—

A triple-pole circuit-breaker with overload trips on at least two phases.

(*b*) For each outgoing three-conductor circuit to which a supply is given from the three conductors :—

Either a triple-pole circuit breaker with overload trips on at least two phases, or a triple-pole linked switch with a fuse on each pole.

(*c*) For each outgoing two-wire circuit to which a supply is given from any two of the three conductors :—

Either a double-pole overload circuit breaker, or a double-pole linked switch with a fuse on each pole.

D. Three-phase Four-wire Systems.

(*a*) For each generator :—

A triple-pole circuit breaker with an overload trip on each phase.

(*b*) For each outgoing three-conductor circuit to which a supply is given from the three conductors :—

Either a triple-pole circuit breaker with overload trips on at least two phases, or a triple-pole linked switch with a fuse on each pole.

(*c*) For each outgoing two-wire circuit to which a supply is given from one of the three conductors and the neutral :—

Either a single-pole overload circuit-breaker, or a single-pole switch and single-pole fuse, placed on that side of the circuit which is connected to one of the three phases.

(*d*) For each outgoing four-wire circuit used to supply a distribution switchboard from which three-wire or two-wire circuits radiate :—

Either a triple-pole circuit-breaker with an overload trip on each phase, or a triple-pole linked switch with a fuse on each pole. A fuse or switch is not to be included in the neutral conductor, but this requirement does not preclude the provision of an isolating link for testing purposes.

4. **Instruments.**—Each main switchboard is to be provided with the following instruments as a minimum :—

A. Two-wire Systems.

(*a*) Where only one generator is installed, one ammeter and one voltmeter, except in the case of tugs and similar vessels.

(*b*) Where more than one generator is installed, the generators not being arranged to run in parallel, an ammeter for each generator and one voltmeter, for use on any generator, fitted with a linked double-pole multiple-way switch or plug.

(*c*) Where more than one generator is installed, the generators being arranged to run in parallel, an ammeter for each generator, and two voltmeters; also a synchronizing device for paralleling purposes if the current be alternating. For compound machines the ammeter is to be connected on the opposite pole from that to which the equalizer connection is made. One of these voltmeters is to be fitted with a linked double-pole multiple-way switch or plug

enabling it to be connected to any one generator before the machine is put in circuit; the other voltmeter is to be permanently connected to the omnibus bars.

B. Three-wire Systems.

In addition to the instruments required for two-wire systems a voltmeter is to be connected between the neutral and each outer omnibus bar; also a central zero ammeter in the main neutral conductor.

C. Three-phase Systems.

(*a*) Where only one generator is installed, an ammeter on each phase, and one voltmeter, except in the case of tugs and similar vessels.

(*b*) Where more than one generator is installed, the generators being arranged to run in parallel, an ammeter on each phase for each generator, two voltmeters and a synchronizing device for paralleling purposes. One of these voltmeters is to be fitted with a linked double-pole multiple-way switch or plug enabling it to be connected to one phase of any one generator before the machine is put in circuit. The other voltmeter is to be permanently connected to one phase of the omnibus bars. All these voltmeter connections are to be made to the same phase in each case.

D. Earth Testing.

Main switchboards, except in the case of tugs and similar vessels where only one generator is installed, are to be provided with suitable means for indicating the state of the insulation of the system, either by lamps, voltmeters, or otherwise.

5. **Switches and Circuit Breakers.**—Each switch, fuse-switch, and other circuit breaker is to comply with the following requirements :—

(*a*) All parts are to be so proportioned that when the normal current for which they are designed flows through

them continuously, their temperature will not rise above that of the surrounding air more than 36° F. (20° C.) in the case of switches rated below 100 amperes, and 54° F. (30° C.) in the case of switches rated at 100 amperes or above.

(*b*) Each fuse-switch when opening the circuit as a switch, and each switch, shall break the circuit without permitting an arc to be maintained when a current 50 per cent greater than that for which it is rated is flowing under a pressure 50 per cent in excess of the pressure of supply. Each fuse-switch when opening the circuit as a fuse, and each circuit breaker, is to comply with the Rule for fusible cut-outs.

(*c*) Each circuit-opening device is to be so constructed and arranged that when placed in the "off" position it cannot accidentally move sufficiently to close the circuit.

(*d*) If the current to be interrupted be sufficiently large to cause damage to the main contacts, suitable arrangements are to be made for the easy renewal of the parts on which the arc is formed.

(*e*) The handles and their attachments are to be mechanically strong, and the exposed surface is to consist entirely of insulating material, or of metal. They are to be so designed and arranged that the hand of the operator cannot accidently touch live metal or be injured through an arc arising from the switch or an adjacent fuse blowing. They are not to operate through open slotted holes.

(*f*) The bases are to be of durable, non-ignitable, insulating, non-absorbent material, and are to comply with the following conditions, viz. :—

(i) Semi-hygroscopic materials such as slate or marble, if used, are to be free from metallic veins, cracks or other defects.

(ii) The slabs are to be planed all over and, if of slate, treated, after drying, with a damp-proof medium, all holes being similarly treated.

(iii) Bolts for securing marble or slate slabs to a metallic framework or case are to be insulated from the slabs, and the latter from the framework or case, by non-hygroscopic insulating bushes and washers.

(*g*) Where switches are not fixed on a switchboard, the live parts are to be enclosed by covers of non-ignitable material. In positions in which the switches are liable to mechanical injury the covers are to be of rigid metal or protected by a suitable guard. In other positions the covers may be either of rigid metal or non-conducting material. Metal cases are to be well clear of live parts, and where the switches are rated for currents exceeding 6 amperes at pressures exceeding 125 volts they are to be lined with non-ignitable insulating material.

(*h*) All switches fixed in positions exposed to the weather, to drip, or to an excessively moist atmosphere, are to be contained in watertight cases, which are to be provided with cable glands or bushings, or be adapted to receive screwed conduit, according to the way in which the cables entering the fittings are run.

(*i*) Each electro-magnetic circuit breaker is to be provided with suitable means of adjustment for determining the current at which it opens, and is to be so arranged that it cannot be held in against this current.

(*j*) Circuit breakers are to be so arranged and placed that no inflammable material is endangered by their coming into action.

6. **Fusible Cut-outs.** — Each cut-out is to comply with the following requirements :—

(*a*) All parts other than the fusible metal are to be so proportioned that their temperature will not rise more than 54° F. (30° C.) above that of the surrounding air when the normal working current for which they are designed flows through them continuously.

(*b*) The fuse is to be of such a size that it would be melted in one minute or less (two minutes or less in the case of a lead-tin alloy fuse) by a current equal to twice the rating of the smallest cable protected by it (as given in **Table IX.**) provided that no fuse smaller than one rated to blow at 7 amperes need be inserted in any final sub-circuit, and that for the purposes of this regulation, the current carrying capacity of a flexible cord or cable is considered to be equal to that of a rubber insulated cable of equal cross section.

Table IX. gives the approximate fusing currents for wires of copper and lead-tin alloy respectively.

(*c*) Each cut-out is to be of an approved type and is to be prominently and permanently labelled with the current carrying capacity of the cable protected by it.

(*d*) Each cut-out is to be provided with a suitable non-ignitable and insulating carrier for the fuse, of such form as to protect a person handling it from shock and burns.

(*e*) Contacts are to be provided on the carrier to which the ends of the fuse can be readily attached.

(*f*) The bases of cut-outs are to be of durable, non-ignitable, non-absorbent, insulating material and are to be provided with fixed circuit contacts of such form as to retain the carrier in position in the presence of vibration.

(*g*) The circuit contacts and their terminals are to be so spaced or shielded that an arc cannot be maintained when a fuse is blown.

(*h*) Fuses are not to be placed in switches, wall plugs, sockets, or in ceiling roses.

(*i*) Where cut-outs are not fixed on a switchboard they are to be grouped on section or distribution boards, or they are to be contained within cases conforming in all respects to the requirements of **clause 7** of this Section.

7. **Joint Boxes, Section and Distribution Boards.** —(*a*) Joint Boxes, Section and Distribution Boards are to be in accordance with **clauses 1 and 2** of this Section, as regards position and general construction. The fuses fitted in section and distribution boards are to conform with **clause 6** of this Section.

(*b*) Each section or distribution board is to be contained within a protecting case, unless of such size that they are contained in separate compartments or spaces in the ship.

(*c*) The cases are to be of metal, except in passenger and other accommodation and in crew spaces, where they may be of wood.

(*d*) All metal cases are to be lined with non-ignitable insulating shields opposite switches and cut-outs, whether such cut-outs are of the enclosed or open type, and all live parts therein are not to be less than $1\frac{1}{2}$ inches clear of the case.

(*e*) All soft-wood cases are to be lined with non-ignitable insulating material, which is to clear all live parts by not less than one inch. Cases of hard-wood, such as teak, need not be so lined.

(*f*) Boxes not provided with backs forming an integral portion thereof are to be fitted with a non-ignitable insulating shield between their contents and the bulkhead, or any other structure, to which they are fixed.

(*g*) Where glass fronts are provided they are to clear all live parts by not less than one inch. Where the boxes are of metal, glass fronts may be regarded as insulating shields.

(*h*) All cases fixed in positions exposed to the weather, to drip, or to an excessively moist atmosphere, are to be watertight, and are to be provided with cable glands or bushings, or be adapted to receive screwed conduit, according to the way in which the cables entering these fittings are run.

CONDUCTORS.

Section 4. 1. **Material.**—(*a*) All conductors are to be of annealed copper conforming to the Standards of the International Electrotechnical Commission Publication No. 28.

(*b*) Where the insulating covering of the conductor contains sulphur, each wire is to be efficiently and uniformly coated with tin free from all impurities.

2. **Minimum Size of Conductor.**—A cable having a conductor of less sectional area than 0·0015 square inch is not to be used except for wiring ornamental fittings which cannot admit this cable; the sectional area of the conductor of the cable for such fittings is not to be less than 0·0006 square inch.

3. **Maximum Size of Single Wire.**—All conductors having an effective sectional area exceeding 0·0033 square inch are to be stranded.

4. **Proportioning of Conductors to Current Carried.**—The size of conductors is to be so selected that the fall of pressure between the main switchboard omnibus bars and any, and every, point of the installation when carrying the maximum load probable under the heaviest conditions of service will not exceed 2 volts plus 3 per cent of the omnibus bar pressure for lighting and 2 volts plus 5 per cent of the omnibus bar pressure for power and heating circuits, provided that in each case the current will not

exceed that given in **Table I.** for each size of conductor when this maximum current is being carried and that **clause 2** of this Section be complied with.

5. **Conductors Intermittently Loaded.—Table III.** gives the maximum permissible currents for half-hour and one-hour ratings, and the sizes of cables which may be used for such ratings in place of the cables specified in **Table I.** for continuous loading. In no case is a shorter rating than one half-hour to be taken whatever may be the degree of intermittency.

6. **Standard Sizes.**—The sizes of conductor shown in **Tables I.** and **II.** are recognised as standard for ships installations. These Tables show the maximum current that each size may carry when the length of conductor is such that the fall of pressure does not exceed that corresponding to the percentage limits laid down in **clause 4** of this Section. The Tables also show the total length of conductor in circuit that will give a drop of pressure of 1 volt when such maximum current is being carried. In **Table I.** allowance is made for the class of insulation with which the conductor is covered.

INSULATION AND PROTECTIVE COVERING OF CABLES.

Section 5. 1. **Types of Cables.**—Only the following types of cables are to be employed, either single, twin, concentric or multicore:—

(*a*) Vulcanized rubber insulated.

(i) Braided.

(ii) Tough rubber sheathed (with or without braiding over the sheathing). For thickness of tough rubber sheathing, *see* **Tables X.** and **XI.**

(iii) Lead covered (with or without braiding over the lead).

(iv) Lead covered and armoured (with or without braiding over the armour).

(v) Braided and armoured (with or without braiding over the armour).

(*b*) Paper insulated.

(i) Lead covered (with or without braiding over the lead).

(ii) Lead covered and armoured (with or without braiding over the armour).

(*c*) Varnished cambric insulated.

(i) The dimensions and current carrying capacities to be as specified in **Tables I., III., V.** and **XII.** respectively.

(ii) The cables are to withstand the pressure test and other tests specified for paper insulated cables for 1000 volts.

(iii) The cables are to be lead covered, or lead covered and armoured (with or without braiding over the lead or armour).

(iv) The installing and fixing of the cables to be in accordance with the regulations for paper insulated cables. (*See* **Section 6.**)

(v) When yellow varnished cambric is used as the di-electric a suitable separator or tinning of the conductor is to be employed to prevent chemical action on the copper.

Where it is desired to use types of cables insulated otherwise than here specified, a report from a recognised testing authority regarding the behaviour, properties and life of the insulating materials employed, is to be submitted for consideration.

2. **Vulcanized Rubber Insulated Cables.**—(*a*) Vulcanized rubber insulated cables are to be insulated with a layer of pure rubber next to the conductor, an intermediate layer of vulcanizing rubber, and an outer jacket of vulcanizing rubber. These three layers are to constitute the dielectric. Alternatively, vulcanized rubber insulated cables may be insulated with a homogeneous dielectric consisting of vulcanized rubber applied in one or more layers, provided the quality of the tinning is such that there is no corrosion of the tinning in the finished cable. The radial thickness of dielectric is not to be less than that specified in **column 3** of **Table IV.** The dielectric is to be surrounded by a layer of waterproof tape, and the whole is to be vulcanized together.

(*b*) Braided cables are to have an exterior braiding of hemp, cotton or jute thoroughly impregnated with a protective compound of such a nature as not to have any deleterious action on the rubber or armouring, as the case may be. The finish of the braiding is to be smooth and uniform.

(*c*) Cable of a higher grade than 600 megohms is not recommended for use in hot situations.

3. **Paper-insulated Cables.**—(*a*) Paper-insulated cables are to be insulated with a covering of paper impregnated with a chemically neutral insulating compound.

(*b*) The radial thickness of dielectric is not to be less than that specified in **column 3** of **Table V.**

4. **Lead Covering.**—(*a*) All cables where required to be lead covered are to be provided with a closely fitting sheath either of commercially pure lead or of an approved lead alloy. The sheath is to be of uniform thickness concentric with the conductor, free from flaws of all kinds and having a smooth exterior surface.

(*b*) The radial thickness of lead is not to be less than that specified in **column 8** of **Table IV.**, **column 4** of **Table V.**, **columns 8** to **10** of **Table X.**, **columns 4** to **7** of **Table XI.** or **columns 4** to **9** of **Table XII.** according to the dielectric used.

5. **Armouring.**—(*a*) Lead-covered cables where required to be armoured are to have over the lead a layer of jute yarn, hessian tape, or other suitable material, in conformity with **Table VI.**, impregnated with a moisture-resisting preservative compound. On the jute is to be bedded an armouring of annealed and galvanized steel wire; each wire is to be of the diameter specified in **columns 5** and **10** of **Table IV.**, **column 6** of **Table V.** or **column 3** of **Table VI.** The wires are to have a uniform lay not exceeding 10 times the diameter of their pitch circle for wires exceeding 0·08 inch diameter, and not exceeding 8 times the pitch circle diameter for smaller wires. The armouring is to be so applied as to present a uniform cylindrical exterior surface, and the overall diameter is not to exceed that specified in **column 11** of **Table IV.** or **column 7** of **Table V.**

(*b*) Braided cables armoured without the interposition of a lead covering are to conform to the above except that the armouring is to be bedded on the braiding.

6. **Testing and Inspection.**—The prescribed tests and inspections are to be made at the place of manufacture prior to despatch and may require to be carried out under the supervision of the Surveyor; but in the event of any of the material proving unsatisfactory in the course of being installed in vessels, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing.

7. **Tests of Dielectric of Cables.**—(*a*) The dielectric of cables, except flexible cords, insulated with vulcanized rubber or impregnated paper is to be such that when the

insulated conductor has been immersed in water for 24 hours it will withstand a voltage test, while still immersed, carried out with alternating current of the appropriate voltage stated below, maintained continuously at the full value for 15 minutes between conductors and between each conductor and earth. The alternating current is to be approximately sine-wave form at any frequency between 25 and 100 cycles per second.

Immersion in water for the purpose of this test may be omitted in the case of lead sheathed cables.

(i) Rubber insulated 250 volt cable—test voltage 1,000.

(ii) Rubber insulated 660 volt cable—test voltage 2,500.

(iii) Paper insulated 1,000 volt cable—test voltage 3,000.

Subsequent to such pressure test and whilst the cable is still immersed in water the insulation resistance at a temperature of 60° F. (15·6° C.), after one minute's electrification at a pressure of at least 500 volts, is not to be less than that given in **Table VII.**

(*b*) The insulation resistance of each insulated conductor of a multicore cable, except flexible cords, is not to be less than that given in **Table VII.** for single conductors of the same sectional area.

(*c*) The insulation resistance of the dielectric separating the two conductors of a concentric cable is not to be less than that given in **Table VII.** for single conductors having the same diameter as the inner conductor.

8. **Multicore Cables.**—Multicore cables are to be either insulated with vulcanized india-rubber or impregnated paper. The insulated cores are to be laid up in a symmetrical manner with jute wormings where required to make the cable of circular section, and be either braided, lead-covered with or without armouring as herein described in the case of single cables.

Multicore and concentric cables are to be made in accordance with the requirements of the Rules relating to the quality, dimensions and tests of single-core cables, so far as they are applicable.

The dimensions of lead covering and armouring are to be in accordance with Tables VI., X., XI. and XII.

INSTALLING AND FIXING OF CABLES.

Section 6. 1. **Cable Sockets and other Connections.**—(*a*) The ends of all cables having a sectional area of 0·04 square inch and above are to be provided with soldering sockets.

(*b*) Soldering fluids containing acid or other corrosive substances are not to be used.

(*c*) When soldering or securing the ends of cables to sockets or terminals, the dielectric is not to be removed farther than is necessary to allow the unreduced conductor to enter and completely fill the socket or terminal.

(*d*) The braid, lead, or other covering over the dielectric, including the tape in contact therewith, is to be cut back at least half an inch from the end of the dielectric.

(*e*) In the case of paper-insulated or varnished cambric insulated cables the exposed conductor and dielectric is to be protected from moisture by being suitably sealed with insulating compound, or in an approved manner with waterproof insulating tapes.

(*f*) The ends of the stranded conductors unprovided with cable sockets are to be made solid by soldering in the case of all conductors insulated with paper, and in the case of those insulated with rubber, where the cables are fixed in damp situations.

2. **Selection of Cable Runs.**—(*a*) Cables are to be run as far as possible in accessible positions, so chosen that they are not exposed to drip or accumulation of water or

oil, to high temperature from boilers, steam pipes, uptakes, radiators, electrical resistances or other hot objects, or to avoidable risk of mechanical damage. Cables are not to be laid under machines or floorplates, unless adequately protected to the satisfaction of the Surveyors. Cables in winch contactor houses are, as far as practicable, to be run clear of the outer casing and away from the heat of the resistances.

(*b*) The runs are to be as direct as possible and an unarmoured rubber-insulated cable is not to be bent to a shorter radius than twice its overall diameter, and an armoured rubber-insulated cable to a shorter radius than three times its overall diameter. Paper-insulated or varnished cambric-insulated cable (whether armoured or not) is not to be bent over a radius shorter than six times its overall diameter.

3. **Support and Protection of Cables.**—(*a*) Cables are to be securely fixed in position.

(*b*) If not exposed to risk of mechanical damage cables may be secured in one of the following ways:—Cables of all classes may be run in wood casing in dry situations. The casing may form part of ornamental woodwork provided that ready access can be had to the cables contained therein. The casing and capping are to be secured by screws, which for the capping are to be of brass and on the outer edges only. Precautions are to be taken to ensure the separation of cables run in separate grooves where cables cross one another.

(*c*) Armoured cables and lead-covered cables, where not run in wood casing, are to be secured by metal clips having smooth or rounded edges, and effectual means are to be taken to ensure that the electrical resistance between any two points of the metallic envelopes of such cables does not exceed 2 ohms. Such clips are to be firmly secured by screws of ample strength, and are to be spaced in accordance with **Table VIII.** Armoured cables having a sectional area of

0·25 square inch and upwards may be carried by metal hangers instead of being secured by clips. Metal staples are not to be used for any class of cable.

(*d*) If cables are exposed to the risk of mechanical damage they are to be efficiently protected by sheet iron plating or by heavy-gauge screwed conduit. Conduits are to be electrically and mechanically continuous across all joints therein, and the entire length is to be effectually earthed. Ventilating outlets are to be provided preferably at their highest and lowest points to allow circulation of air and to ensure that no water can lodge in any part of the conduit. All open ends of conduit are to be bushed to avoid abrasion of the cable coverings and all openings are to be protected against the direct access of sea water.

(*e*) Cables in machinery spaces, galleys, laundries, bathrooms and lavatories or where unavoidably exposed to the weather or to the action of sea water are to be either lead covered with or without further protection, or to be run in conduit as required by paragraph (*c*).

(*f*) Cables entering refrigerating chambers are to pass normally through the insulation of the chamber, and are to be protected by a continuous lead tube flanged over at each end.

(*g*) Cables fixed within refrigerating chambers are not to be embedded in the insulation, but are to be in full view throughout their length, and are to be supported by clips made of porcelain, hard wood, or other non-metallic and non-hygroscopic material. In all cases the cables are to be sheathed with commercially pure lead or with lead alloy, in accordance with **Section 5, clause 4.** If sheathed with commercially pure lead they are in addition to be braided as laid down in **Section 5, clause 2** (*b*).

(*h*) Cables of opposite polarity may be bunched in conduit if carrying direct current; if carrying alternating

current they are to be bunched. Where protected by wood casing, cables of the same polarity may be bunched. Lead-covered and armoured cables may in all cases be bunched, whatever their polarity.

(*i*) Every lead-covered cable, whether armoured or not, and every armoured cable, is to have its lead covering and/or armouring efficiently earthed at both ends, except in the case of such cables forming final sub-circuits, which are to be earthed at the supply end only. Effectual means are to be taken to ensure that all metallic envelopes of cables are made electrically continuous throughout their length. All earthing connections are to be effected by soldered joints or clamps, or alternatively by glands specially designed for the purpose of forming part of joint boxes or similar fittings in which cables terminate, and are to conform to the requirements of **Section 7, clause 4**, as far as they are applicable.

4. **Joints during Erection.**—(*a*) All connections between large rubber-insulated cables are to be made by means of clamped sleeves or tees in joint boxes constructed in accordance with **Section 3, clause 7**, and those between small cables and between small cables and flexibles by means of clamped connections contained within suitable receptacles, which in the case of lamp fittings may form part of such fittings. Joints in flexibles are not permissible.

(*b*) Connections between lead-covered paper-insulated or varnished cambric-insulated cables may be made by the same means as for rubber-insulated cables, the insulation at their ends being suitably sealed against moisture; or the conductors may be joined by means of copper sleeves, the whole being sweated together. Joints made in this manner are to be lapped with paper or pure cotton tape, impregnated immediately before use, and are to be enclosed in boxes, or, preferably, lead sleeves or tees wiped on to the cable coverings, these receptacles being filled with an insulating

compound impervious to moisture. Lead sleeves and tees are to be painted with two coats of tough elastic enamel on completion of the joint.

5. **Watertight Glands and Deck Tubes.**—All cables passing through decks or watertight bulkheads are to be provided with deck tubes or watertight glands.

6. **Cables passing through Beams and Non-Watertight Partitions.**—Unarmoured cables passing through beams and non-watertight partitions are to have the holes through which they pass bushed with lead or other soft non-ferrous material.

MAIN DISTRIBUTION.

Section 7. 1. **Subdivision of Circuits.**—(*a*) Each installation is to have its individual lamps and other devices consuming small currents grouped into circuits taking not more than 6 amperes, and the maximum number of points on each such final sub-circuit is not to exceed ten. These final sub-circuits are to radiate from a sub-distribution board.

NOTE :—A point is the termination of the wiring for attachment to a fitting for one or more lamps or other consuming devices.

(*b*) Each sub-distribution board and each lamp or other consuming device taking more than 6 amperes is to be connected to a separate way on a section or main distribution board. Each section or main distribution board in turn is to be connected either to a separate way on the main switchboard or to one way of a distribution board for larger currents, which in turn is to be connected to the main switchboard or to one way of a distribution board for still larger currents. The number of such distribution boards intervening between the final sub-distribution boards and the main switchboard will depend upon the size and disposition of the installation.

(*c*) Where three-wire distribution is employed and the pressure across the outer conductors exceeds 250 volts the pressure between any two points in one space or compartment where portable fittings, appliances or accessories are likely to be used is not to exceed 250 volts unless the fittings, appliances or accessories between which there may be a higher pressure are so situated that they cannot be brought within 6 feet of each other.

2. **Control of Circuits.**—(*a*) Each two-wire circuit on a distribution board whether supplied from a two-wire system, from a three-wire system with insulated neutral, from a three-phase four-wire system with insulated neutral, or from a three-phase three-wire system, is to be controlled by a fuse on each insulated pole, and, except in the case of a sub-distribution board, by a switch on one insulated pole.

(*b*) Fuses or switches are not to be connected to that pole of the circuit which is either earthed or derives its polarity from an earthed conductor.

(*c*) The neutral conductor of a three-wire system or of a three-phase four-wire system whether earthed or not, is never to be interrupted by a fuse or switch, but an isolating link may be fitted for testing purposes in the neutral or any other conductor, provided it be arranged for use by skilled persons only.

(*d*) Each three-wire circuit supplied from all three conductors of a three-phase system is to be controlled by a triple-pole circuit breaker with overload trips on at least two phases, or by a triple-pole linked switch and by a fuse on each pole.

3. **Earthing of Neutral.**—Where the distribution is effected on the three-wire system, whether with direct or alternating current, the neutral may be earthed at one or more points whatever the pressure of supply, but if the

pressure exceed 250 volts (as allowed for a direct-current supply only) whether across the outer conductors of a three-wire system or on a plain two-wire system, the neutral is to be solidly and permanently earthed at one point at least ; in the latter case a neutral point is to be provided by means of static coils on the generator.

4. **Earthing Connections.**—(*a*) Each conductor used for earthing purposes which does not normally carry current, is to be of copper having the same sectional area as the working conductor, but not less than 0·003 square inch, for all sizes up to 0·007 square inch. Above this size a conductor of not less than 0·007 square inch is to be provided for every 50 amperes of working current or part thereof. Its sectional area need not exceed 0·1 square inch.

(*b*) Each conductor used to carry the working current of a circuit to the ship's structure on the single-wire system of distribution is to be of the same sectional area as the corresponding conductor of the insulated portion.

(*c*) All connections to the ship's structure are to be in accessible positions.

(*d*) Solid wires are to be connected to the ship's structure by being formed into a hook and placed under a brass washer and secured by a screw of not less than $\frac{3}{8}$ inch diameter used for this purpose only.

(*e*) Cables are to be provided with cable sockets secured to the ship's structure by screws of not less than $\frac{3}{8}$ inch diameter.

(*f*) In all cases care is to be taken to ensure bright metallic surfaces at the contact areas immediately before screwing up.

5. **Two-wire Circuits supplied at Pressures exceeding 250 Volts.**—Where a pressure exceeding 250 volts (as

is allowed for a direct-current supply only) is employed, the following conditions are to be observed :—

(*a*) Machines, whether generators or motors, are not to be of the open type.

(*b*) Motors only are to be supplied at such higher pressure.

(*c*) Only motors exceeding 3 brake horse-power are to be supplied at such higher pressure.

(*d*) Portable motors, whatever their size, are not to be supplied at such higher pressure.

(*e*) All metal work other than that designed to be alive is to be efficiently connected with earth.

(*f*) The wiring is to be carried out wholly with lead-covered and armoured or braided and armoured cables and the armour (and the lead, if there be lead) is to be electrically continuous and efficiently connected with earth.

(*g*) The motors and all accessory apparatus in connection therewith are to be so constructed, enclosed, and protected that there will be no danger of any shock in the ordinary handling thereof, and that the danger of fire under abnormal conditions will be reduced to a minimum.

(*h*) All switchboards are to have their live parts protected against accidental contact.

6. **Alternative Lighting.**—Alternate groups of lamps in engine and boiler-rooms are to be supplied from circuits so arranged that the fusing of any one cut-out (other than a cut-out on the main switchboard) will not leave these spaces in darkness.

7. **Emergency Supply.**—(*a*) Where the Board of Trade require an emergency supply to be provided it is to be adequate in amount, and so disposed as to meet all requirements concerning safety imposed by the Board of Trade.

(*b*) The emergency circuits are to be connected direct to a change-over switch, or switches, fitted near the source of emergency supply, enabling these circuits to be quickly transferred from the ordinary to the emergency source.

8. **Interference with Magnetic Compasses.** — (*a*) Dynamos, motors, secondary batteries, control gear, resistances and all apparatus producing an external magnetic field when in use are to be fitted at such distances from the compass bowl, as will reduce the magnetic field produced by such apparatus to a negligible value thereat.

(*b*) Single-conductor circuits carrying continuous current are not to be fitted within 30 feet of standard and steering compasses. In order that the lead and return currents may neutralize one another in two-conductor systems, conductors in the vicinity of the compass are preferably to be twin ; if separate, they are to be fixed as close to one another as possible, and be equidistant from the compass throughout their length. Conductors within the compass binnacle are to be as short and direct as possible ; if separate, they are to be twisted together and are not to be coiled into spiral loops.

(*c*) Incandescent electric lamps employed for illumination of the compass card are not to consume more than 0·6 ampere. Such lamps are to be so placed that all live parts are at a distance of not less than 7 inches from any part of the magnetic system of the compass.

(*d*) Careful tests are to be made during the adjustment of the compasses. The effect of switching on and off circuits, motors and other electro-magnetic apparatus within the vicinity of the compasses, is to be noted and careful records are to be kept of any errors observed, whether corrected or not.

9. **Navigation Lamps.**—(*a*) Each navigation lamp is to be separately wired and is to be controlled by a separate switch, and separate fuses which are to be double-pole unless

one conductor of the system be earthed; such switches and fuses are to be grouped in a position accessible only to the officers of the watch.

(*b*) Each navigation lamp is to have an automatic indicator in its circuit placed on or adjacent to its switch and arranged to give an aural or visual signal in case of extinction of the light by breakage of the lamp filament or from other cause.

(*c*) Carbon or metal filament vacuum lamps with bayonet socket caps are to be used. The illuminating power of the lamps is to be 32 candles.

The filament is to be of the cylindrical ("squirrel cage") type. The diameter of the cage forming the filament is not to be less than 1 inch or more than $1\frac{3}{8}$ inch. Double filament lamps are not to be used.

(*d*) The lamp is to be fitted in a vertical position with the cap downwards. Should the lantern be provided with a dioptric lens the luminous centre of the source of light is to coincide with the focal centre of the lens.

NOTE.—This clause does not apply in the case of tugs and similar vessels.

10. **Shore Connections.**—Where provision for a supply of electrical energy from the shore or other external source is desired, a suitable connection box or boxes is to be fitted in a position convenient for the reception of portable cables from the external source and containing terminals of ample size and of such form as to enable the conductors to be efficiently clamped therein. The terminals are to be connected to the main switchboard by suitable cables, permanently fixed, through a circuit breaker, or switch and fuses on each pole, of sizes appropriate to the proposed shore supply but not greater than the capacity of the main omnibus bars. A circuit breaker or fuses of appropriate size is, in addition, to be fitted as near as possible to the incoming supply terminals.

SECONDARY BATTERIES FOR LIGHTING AND POWER.

Section 8. 1. **Construction.**—The cells of secondary batteries are to be of such construction as to prevent spilling of the electrolyte through the motion of the ship and to prevent the emission of acid spray on surrounding objects.

The containers are to be of strong construction and of non-brittle material; they are not to be of celluloid. The plates are to be of such dimensions and so arranged that they are firmly secured against motion within the containers.

2. **Arrangement.**—Each battery is to be so arranged that a potential difference exceeding 50 volts does not exist between adjacent cells and that each cell will be readily accessible from the top and from at least one side; if possible they are to be arranged in a single tier. The cells are to be carried by glass or vitreous porcelain insulators provided with suitable channels to contain oil, and insulators of similar material, but not necessarily filled with oil, are to be employed to prevent any movement of the cells arising from motion of the ship.

3. **Position, Protection and Ventilation of Battery Compartment.**—(*a*) The position of the battery compartment is to be such that the magnetic compasses are not affected by currents in the battery or in the connections thereto.

(*b*) Where acid is used as an electrolyte for the cells, the deck below the cells is to be lined with lead or other acid-resisting material so as effectually to prevent any acid getting into contact with the structure of the ship. All metal-work within the compartment, including exposed metal on the battery and its connections, is to be protected with acid-resisting paint. All trunks or other parts exposed to acid fumes or gases are to be similarly protected.

(*c*) The compartment in which batteries are fixed is to be thoroughly well ventilated by means of supply and exhaust ventilators, independent of one another, so arranged that it will be impossible for gases to accumulate in large quantities during charge or discharge of the battery.

4. **Control.**—(*a*) Suitable means are to be provided for controlling the current with which a battery is being worked. As a minimum this is to comprise an automatic cut-in and cut-out switch and fusible cut-out, or alternatively, a circuit breaker with overload and reverse-current trips.

(*b*) Switches, fuses, and other electrical fittings, liable to cause an arc are not to be placed within the battery room, but a fuse is to be placed in each conductor immediately outside the battery room, such conductors being spaced at least 3 inches apart on insulators in the battery room, and the holes in bulkheads or decks through which they pass being substantially and tightly bushed, a separate bush being provided for each cable.

(*c*) All connections within an acid battery room are to be either of bare metal or lead-covered cables.

FITTINGS.

Section 9. 1. **General Requirements.**—(*a*) Fittings are to be weatherproof on weather decks, in stokeholds and engine rooms, and wherever exposed to drip or condensed moisture. In spaces in which goods are liable to be stacked in close proximity to them, they are to be provided with substantial metal guards.

(*b*) Open type fittings whether fixed or portable are not to be used in spaces where

(i) Inflammable or explosive dust or gases are liable to be present or where inflammable goods are

SECONDARY BATTERIES FOR LIGHTING AND POWER.

Section 8. 1. **Construction.**—The cells of secondary batteries are to be of such construction as to prevent spilling of the electrolyte through the motion of the ship and to prevent the emission of acid spray on surrounding objects.

The containers are to be of strong construction and of non-brittle material; they are not to be of celluloid. The plates are to be of such dimensions and so arranged that they are firmly secured against motion within the containers.

2. **Arrangement.**—Each battery is to be so arranged that a potential difference exceeding 50 volts does not exist between adjacent cells and that each cell will be readily accessible from the top and from at least one side; if possible they are to be arranged in a single tier. The cells are to be carried by glass or vitreous porcelain insulators provided with suitable channels to contain oil, and insulators of similar material, but not necessarily filled with oil, are to be employed to prevent any movement of the cells arising from motion of the ship.

3. **Position, Protection and Ventilation of Battery Compartment.**—(*a*) The position of the battery compartment is to be such that the magnetic compasses are not affected by currents in the battery or in the connections thereto.

(*b*) Where acid is used as an electrolyte for the cells, the deck below the cells is to be lined with lead or other acid-resisting material so as effectually to prevent any acid getting into contact with the structure of the ship. All metal-work within the compartment, including exposed metal on the battery and its connections, is to be protected with acid-resisting paint. All trunks or other parts exposed to acid fumes or gases are to be similarly protected.

(*c*) The compartment in which batteries are fixed is to be thoroughly well ventilated by means of supply and exhaust ventilators, independent of one another, so arranged that it will be impossible for gases to accumulate in large quantities during charge or discharge of the battery.

4. **Control.**—(*a*) Suitable means are to be provided for controlling the current with which a battery is being worked. As a minimum this is to comprise an automatic cut-in and cut-out switch and fusible cut-out, or alternatively, a circuit breaker with overload and reverse-current trips.

(*b*) Switches, fuses, and other electrical fittings, liable to cause an arc are not to be placed within the battery room, but a fuse is to be placed in each conductor immediately outside the battery room, such conductors being spaced at least 3 inches apart on insulators in the battery room, and the holes in bulkheads or decks through which they pass being substantially and tightly bushed, a separate bush being provided for each cable.

(*c*) All connections within an acid battery room are to be either of bare metal or lead-covered cables.

FITTINGS.

Section 9. 1. **General Requirements.**—(*a*) Fittings are to be weatherproof on weather decks, in stokeholds and engine rooms, and wherever exposed to drip or condensed moisture. In spaces in which goods are liable to be stacked in close proximity to them, they are to be provided with substantial metal guards.

(*b*) Open type fittings whether fixed or portable are not to be used in spaces where

(i) Inflammable or explosive dust or gases are liable to be present or where inflammable goods are

stored. In such situations lamp fittings are to be of strong construction, having air-tight external globes of thick glass, provided with substantial guards.

(ii) In positions in which the lamp is either near to, or can swing near to, readily combustible materials.

(*c*) Open type fittings are not to be furnished with combustible shades unless such shades are kept free from contact with the lamps by suitable guards or supports. Celluloid is not to be used in any situation near a lamp.

(*d*) Switches and other fittings liable to arc when operated are not to be installed in bunkers or other spaces in which inflammable or explosive dust or gases are liable to be present, whether controlling lights in such spaces or not.

(*e*) Lamp fittings installed in spaces allotted alternatively to passengers or cargo are to be of extra strong construction so designed as to admit of easy removal of lamps, globes and guards, provision being made for the protection of the base of the fitting and its lampholder after such removal by a screwed metal cover. Alternatively, the complete fitting may be protected by a strongly constructed hinged or screwed metal cover completely enclosing it. In either case the enclosure is to be such that the fitting cannot be tampered with easily. Switches and fuses controlling lights in spaces of this kind are, wherever possible, to be placed outside the spaces. Where this is impracticable they are to be contained in strong iron boxes with iron covers provided with padlocks.

(*f*) Fittings and accessories are to be so designed and insulated conductors so installed, that no stress can be applied by the conductors to any terminal to which they may be connected.

(*g*) Enclosed lamp fittings are to be suitably ventilated.

2. **Switches.**—Switches are to be constructed wholly of durable non-ignitable, non-absorbent materials.

3. **Lampholders.**—(*a*) Lampholders are to be of the Goliath type for lamps consuming more than 300 watts.

(*b*) Lampholders are to be wholly of non-ignitable material and all metal parts are to be of robust proportions. Goliath holders are to be provided with efficient means for locking the lamp in the holder.

(*c*) Lampholders in weatherproof portable fittings are to have their uninsulated metal parts in metallic contact with the frames of such fittings.

(*d*) Lampholders in open type portable fittings are to be insulated from the fitting by means of insulating material of adequate mechanical strength which will not soften at 302°F. (150° C.) and be so shielded by means of similar insulating material that they cannot be touched accidentally by a person using the fitting or replacing a lamp. This shield is to be so extended as to prevent the lamp cap being touched when the lamp is in the holder.

(*e*) Small and miniature lampholders are not to be employed on systems exceeding 110 volts.

4. **Ceiling Roses.**—Ceiling roses are to be of non-ignitable non-conducting non-hygroscopic material.

5. **Plugs and Sockets.**—(*a*) The live parts of plugs and sockets are to be so proportioned that their average temperature will not rise more than 54° F. (30° C.) above that of the surrounding air when the normal working current is flowing through them continuously.

(*b*) Watertight plugs and sockets are to be employed on weather decks, in stokeholds and engine rooms, and wherever exposed to drip or condensed moisture.

6. **Searchlight Lamps.**—(*a*) Searchlight lamps are to have the whole of their live parts insulated from the frame or case.

(*b*) All parts of a searchlight lamp which have to be handled for its operation or adjustment while in use are to be insulated from the circuit with strong, non-ignitable material, of substantial proportions, and be so disposed that there is no risk of shock to the operator.

(*c*) Each searchlight circuit is to be controlled by a fuse on each insulated pole, and by a double-pole linked switch.

7. **Arc Lamps.**—(*a*) Arc lamps, other than searchlight lamps, are to have the whole of their live parts insulated from the frame or case.

(*b*) Each arc lamp is to be provided with a globe or lantern arranged to intercept falling particles of carbon, and with wire netting or other means of preventing pieces of broken glass falling.

(*c*) Each arc lamp circuit is to be controlled by a fuse and switch on each insulated pole. Where more than one pole is insulated the switches are to be linked.

(*d*) Arc lamps are not to be fitted in spaces in which combustible goods are stored, or in which inflammable gases may accumulate.

HEATING AND COOKING APPLIANCES.

Section 10. 1. **General Construction.**—(*a*) All appliances are to be so constructed and mounted that their supports and those parts which have necessarily to be handled in their operation cannot become heated to a temperature exceeding 130° F. (54° C.). The heating elements are to be so arranged that they can be readily replaced.

(*b*) The high temperature parts of radiators are to be suitably guarded.

(*c*) The junction between the elements and switches or external connecting leads are to be effected without solder by suitable connections, which are to be so placed that the temperature of no part of the switch or terminal connections can rise above 176° F. (80° C.).

(*d*) All connections between elements or between elements and main terminals or switches are, unless self-supporting or rigidly fixed in position, to be continuously insulated with suitable non-ignitable material.

(*e*) All live parts of cooking appliances are to be so guarded that the cooking utensils cannot be brought into contact with them.

2. **Provision for Earthing.**—All appliances for pressures exceeding 150 volts, whether portable or fixed, are to be provided with a terminal or other suitable means for earthing all uninsulated parts and such terminals are to be efficiently connected to earth.

3. **Control.**—(*a*) All appliances are to be protected by a fuse on each insulated pole.

(*b*) Appliances whether portable or fixed are to be controlled as a whole by a switch, which in all cases is to be permanently fixed.

4. **Portable Appliances** are to be of such shape or so weighted that they cannot easily be overturned and these are to have suitable stowage positions.

5. **Protection of Inflammable Materials.**—All inflammable materials in the vicinity of heating and cooking appliances where fitted in the ship are to be protected by suitable fire-resisting materials.

6. **Air Heaters.**—(*a*) The construction of heaters is to be such as to heat the surrounding air by convection. Heaters in which the elements are caused to glow or reach such a temperature as will ignite explosive vapours, dust, etc., in the surrounding atmosphere are not to be used, except where fitted in suitable situations in public rooms.

(*b*) Heaters are to be durable and all parts should be of strong construction. The protecting guards are to be strong enough to resist being forced against any current carrying part. The openings are to be of small size to prevent the heating elements from being short-circuited or injured by accident.

(*c*) Where installed on a deck or bulkhead they are to be so mounted that there will be at least 2 inches of air space between the heater and the deck or bulkhead. They are to have non-inflammable heat resisting material between the heater and the surface on which they are mounted or to which they are adjacent.

(*d*) Where the heaters are of the portable type a suitable clip or bracket is to be fitted for holding the heater in a fixed position.

MOTORS.

Section 11. 1. **General Construction.**—(*a*) All working parts are to be readily accessible.

(*b*) All field coils are to be self-contained and readily removable for replacement.

(*c*) Motors are to be so constructed, erected and supported that when running at any and every working speed all revolving parts are well balanced and do not give rise to any appreciable vibration.

2. **Rating of Motors.**—Motors rated at more than one brake horse-power are to conform to Appendix No. 2, except that in tropical climates or where fixed in specially hot

situations on the ship, the rated full load is not to be exceeded and the temperature rise at rated full load for motors not totally enclosed is not to exceed 63° F. (35° C.) on the windings and 72° F. (40° C.) on the commutator; for totally enclosed machines, the temperature rise at full load is not to exceed 81° F. (45° C.) on the windings and 90° F. (50° C.) on the commutators, all temperatures being measured by thermometer.

Where the temperature of the compartment is liable to exceed 120° F. (49° C.), **clause 6** (*g*) of this Section is to be complied with.

The tests on all motors engaged on essential services, such as those enumerated in **Section 18**, are to be carried out at the makers' works, and a certificate giving the results is to be submitted for approval. Machines of 100 B.H.P. and over are to be inspected by the Surveyors during manufacture and testing.

3. **Brushes.**—(*a*) The brushes are to be of carbon, and are to be provided with flexible copper connections.

(*b*) Means are to be provided for the adjustment of the brushes longitudinally, so that they may be staggered in such a manner that in multipolar machines every part of the commutator working surface will be swept by an equal number of positive and negative brushes in order to avoid unequal wear.

4. **Terminals.**—(*a*) Suitable terminals clearly marked and provided with cable sweating sockets are to be provided in an accessible position, convenient for wiring.

(*b*) The terminals are to be so spaced or shielded that they cannot be accidentally earthed, short-circuited, or touched.

(*c*) The frame of every motor is to be provided with a suitable terminal to which the earthing lead is to be connected.

5. **Lubrication.**—(*a*) Motors are to be efficiently and continuously lubricated automatically with the base of the machine inclined at any angle up to 15 degrees from the horizontal in any and every direction.

(*b*) If ring lubrication be employed, the rings are to be so constrained that they cannot leave the shaft.

(*c*) Oil flingers, or other suitable means, are to be provided to prevent the lubricant creeping along the shaft or otherwise gaining access to the insulation of the machine or any live part thereof.

(*d*) Each oil-lubricated bearing is to be provided with a suitable overflow which, while permitting efficient lubrication when the motor is running, is to prevent excess of oil.

6. **Position in Ship.**—(*a*) Motors are, wherever possible, to be placed in well ventilated compartments in which inflammable gases cannot accumulate, and in all cases they are to be fixed clear of all inflammable material. Where these conditions cannot be complied with, motors fitted in such compartments are to be of the flame-proof or forced-draught type, with supply and exhaust pipes or ducts taken outside the compartments.

(*b*) The motors are, as far as possible, to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam, or oil.

(*c*) Motors required to work under water are to be of the immersible type.

(*d*) Motors essential to the safety of the ship in the event of damage are to be so installed as to be capable of running for a reasonable period after the compartment in which they are situated has been flooded.

(*e*) In all sea-going ships, the motors are, wherever possible, to be placed with their axes of rotation in a fore and aft direction.

(*f*) Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above, any motor, unless it be of the totally enclosed, pipe-ventilated, induced-draught, forced-draught, drip- or flame-proof type.

(*g*) Motors fitted in compartments in which the temperature is liable to exceed 120° F. (49° C.) are to be specially ventilated with air at or below that temperature, or to be constructed with Class B insulation, in accordance with Appendix No. 2 or so constructed that the final temperatures during normal working do not exceed the temperature rise permitted in Appendix No. 2 plus 40° C.

CONTROL GEAR AND RESISTANCES.

Section 12. 1. General Construction.–(*a*) Generator field and motor speed regulators, starters, and controllers, are to be constructed wholly of durable, non-ignitable, non-hygroscopic material, and unless otherwise guarded from approach are to be enclosed in non-ignitable cases.

(*b*) All switch parts and protective devices are to be so proportioned that their temperature will not rise more than 54° F. (30° C.) above that of the surrounding air, when the normal working current for which they are designed flows through them continuously.

(*c*) The contact-making faces are to be sufficiently numerous to prevent destructive arcing, and are to be readily renewable without dismantling the gear.

(*d*) Handles and their attachments are to be mechanically strong, and so designed and guarded that the hand of the operator cannot touch live metal.

(*e*) All live parts are to be enclosed by metal covers, which are to be clear of such live parts by not less than $\frac{3}{4}$ inch. Those portions of the cover in proximity to working contacts are to be lined with non-ignitable insulating material.

2. **Resistances.**—(*a*) Resistances are to be so proportioned that they do not rise to such a temperature as seriously to impair their durability.

(*b*) Internal connections are not to be soldered, and all such connections, unless self-supporting or rigidly fixed in position, are to be continuously insulated with porcelain beads or other approved non-ignitable insulation.

(*c*) Suitable terminals with cable sockets are to be provided for the attachment of external leads, and are to be so situated that such leads are not exposed at any point to a high temperature.

3. **Position in Ship.**—(*a*) Control gear, wherever possible, is to be placed in positions in which inflammable gases cannot accumulate. Where such conditions cannot be complied with, such apparatus is to be flame-proof.

(*b*) Control gear, as far as possible, is to be placed in positions in which it will not be exposed to risk of mechanical injury or to damage from water, steam, or oil. Where necessarily exposed to such conditions, it is to be totally enclosed.

(*c*) All resistances are to be placed in well-ventilated compartments in which inflammable gases cannot accumulate, and in such positions as to be clear of all inflammable material. Unprotected wood-work or other combustible material is not to be fitted within a distance of 6 inches measured horizontally from, or within 24 inches measured vertically above, the frames or the cases containing them.

INTERNAL COMMUNICATIONS.

Section 13. 1. **Construction of Transforming Plant.**—Motor generators and static transformers used for the reduction of pressure for communication circuits are, together with their control gear, to be constructed in accordance with the regulations for similar plant employed for lighting and power supply.

2. **Batteries.**—Primary and secondary batteries are to be readily accessible at all times. Means are to be provided to prevent liquid from wet primary cells coming into contact with the wooden floor or framework of the ship. Secondary batteries are to be fitted in accordance with **Section 8.**

3. **Construction of Apparatus.**—All apparatus for communications is to be constructed to take the full pressure of the source of supply without the interposition of any external resistance, and, if the pressure of supply exceeds 25 volts, all circuits, switches, resistances, distribution boards and accessories required in connection therewith are to be designed and fitted throughout in all respects in accordance with the regulations for lighting and power circuits.

4. **Communication Cables.**—(*a*) Cables used for the purpose of internal communication are to be of one or other of types specified in **Section 5, clause 1,** and are to be fitted in a similar manner to cables installed for the lighting and power supply of the ship, and they are, as far as possible, to be kept separate unless the lighting and power cables are protected by one or more of the following, with or without braiding overall :—

(i) Lead covering,

(ii) Steel wire armouring,

(iii) Tough rubber sheathing.

(*b*) Communication cables, run in wood casing, are not to be fixed in the same groove as cables supplying lighting and power.

5. **Protection of Circuits.**—In all cases in which secondary batteries, motor generators or static transformers are employed, the main circuit or circuits are to be protected by a fuse or fuses, but fuses need not be fitted in branch circuits if the pressure does not exceed 25 volts or in any circuit supplied from primary batteries.

LIGHTNING CONDUCTORS.

Section 14. Lightning Conductors.—(*a*) Lightning conductors are to be fitted to each mast of all wooden vessels and of steel vessels having wooden masts. They need not be fitted to steel vessels having steel masts.

(*b*) In wooden ships or ships sheathed with wood the lightning conductors are to be composed of a continuous copper tape or rope, having a section not less than 0·15 square inch which is to be riveted or clamped to a suitable copper spike attached to the mast-head. If of tape the lower end is to terminate at the point at which the shrouds leave the mast, and to be securely clamped to a copper rope of not less than $\frac{1}{2}$ inch in diameter. This copper rope is to be led down the shrouds and to be securely clamped to a galvanized iron plate not less than 2 square feet in area fixed well below the light-load water-line and attached to the ship's side.

(*c*) In steel ships fitted with wooden masts the lightning conductors are to be composed of copper tape terminating in a spike, as set forth in paragraph (*b*). At the lower end this copper tape is to be securely attached to the nearest metal forming part of the hull of the ship.

(*d*) In all cases the lightning conductor is to be so run as to avoid sharp bends in the conductor.

(*e*) It is recommended that suitable means should be provided to enable ships when in dry dock to have their lightning conductors connected to an efficient earth on shore.

SPECIAL REQUIREMENTS FOR SHIPS CARRYING OIL HAVING A FLASH POINT LESS THAN 150° F. (65·5° C.).

Section 15. 1. Nature of Supply.—The pressure of supply is not to exceed the following values :—

(*a*) With direct current

(i) For power, 220 volts.

(ii) For lighting and heating, 110 volts.

(*b*) With alternating current

For all purposes, 110 volts.

2. **Switchboards.**—(*a*) Each outgoing circuit from the main switchboard and every branch circuit controlling either a junction or section fuse board is to be provided with a double pole linked switch.

(*b*) The cases of all joint boxes, section and distribution boards are to be wholly of metal, and all cables are to enter the cases through watertight glands. Distribution boards in officers' accommodation may be constructed in accordance with **Section 3, clause 7.**

3. **Protective Covering of Cables.**—All cables are to be lead-covered or lead-covered and armoured.

4. **Distribution.**—Main distribution for direct current systems (*i.e.*, between switchboards and distribution boards, or between distribution boards and sub-distribution boards) is to be effected wholly on the two-wire two-conductor system with entirely separate cables, both insulated, for the respective poles; no part of the system shall be earthed. Main distribution for three phase alternating current systems is to be effected wholly with multicore cables.

5. **Fuses.**—Fuses are to be of an approved filled cartridge type.

6. **Dangerous Spaces.**—(*a*) Lamps, fittings, appliances of any kind, and wiring are not to be fitted in, or enter, any of the following dangerous spaces: Oil-holds, cofferdams.

(*b*) Pump rooms may be lighted by lamps wired wholly outside the space and separated from the interior by an air-tight stout glass bowl.

(*c*) Lamps in pump-rooms, 'tween decks and spaces immediately adjoining oil-holds are to be contained in gas-tight fittings, the wiring being enclosed in gas-tight tubing. The switches controlling the lamps are to be wholly outside these spaces. These switches are in all cases to be double-pole.

(*d*) Portable lamps other than self-contained battery-fed lamps of a type approved by the Home Office for use in fiery mines are not to be used in dangerous spaces.

7. **Lighting and Heating.**—Circuits for supplying lighting and heating are not to be connected to any source of supply having a pressure in excess of 110 volts.

8. **Galleys.**—Cooking and heating appliances in galleys may be supplied with 220 volts direct current, provided they be wholly within the galley space and the galley be situated in an approved position well clear of inflammable gases and dangerous spaces. In other parts of the vessel the pressure of supply for cooking apparatus is not to exceed 110 volts.

SPECIAL REQUIREMENTS TO BE COMPLIED WITH WHERE THE CONSTANT CURRENT SERIES SYSTEM IS USED.

Section 16. 1. **Generators and Motors.**—(*a*) Every generator is to be provided with an automatic circuit closer so arranged as to short-circuit the generator in the event of an open circuit occurring at any point in the system.

(*b*) Generators or motors are not to be of the open type.

2. **Bare Conductors.**—All bare conductors (including radiator elements) are to be totally enclosed in metal cases and all access doors or covers so interlocked that the conductors contained therein will be accessible only when entirely disconnected from the system.

3. **Switches.**—(*a*) The movement of all switches is to be effected without breaking the main circuit.

(*b*) When a current consuming device is "switched-off" by its main switch it shall be totally disconnected on both poles from the system.

4. **Earthing.**—No part of the system is to be earthed.

TRIALS.

Section 17.—Before the installation is put into service the following tests are to be carried out :—

1. **Insulation Resistance.**—(*a*) The insulation resistance is to be measured by applying a direct-current pressure not

less than twice the working pressure between earth and the whole system of conductors and any section thereof, with all lamps and fuses in place, and all switches on.

(*b*) The insulation resistance of the lighting circuits so measured is not to be less in megohms than 10 divided by the number of points on those circuits, except that the insulation resistance of any final lighting sub-circuit need not exceed 1 megohm.

(*c*) The insulation resistance between the case or framework and every live part of each individual dynamo, motor, heater, arc lamp or other appliance, complete with its switch and control gear, regulating resistance and similar accessories, is not to be less than half a megohm.

2. **Running Order.**—All generators are to be run in turn or simultaneously; all main switches and current breakers are to be operated, and all lamps, heaters, motors and other appliances run, though not necessarily under full load or simultaneously. During this test everything is to operate satisfactorily, and the specified drop in pressure on any part of the installation is not to exceed that laid down in **Section 4, clause 4.**

This trial is to be in addition to, and not in substitution for, the acceptance trials of the individual items of plant at the makers' works.

SPARE GEAR.

Section 18.—In vessels engaged on open sea service, the articles mentioned in the following list (so far as they are applicable) will be required to be carried, viz.:—

For the Generators.

For each size of generator:—

2 brush holders.

1 set of carbon brushes for one machine.

1 set of any special spanners required.

For the Motors.

For each size of motor engaged on essential services, such as those enumerated below :—

2 brush holders.
1 set of carbon brushes for one machine.
1 set of any special spanners required.

The following are motors for which spare gear is required :—

Auxiliary compressors.
Scavenge blowers.
Cooling water pumps for main engines.
Oil fuel pumps.
Oil separators.
Fans for forced draught to boilers.
Condenser circulating pumps.
Air pumps.
Feed water pumps.
Fire pumps.
Bilge pumps.
Steering gear.
Windlasses.
Ventilating fans for engine room and boiler rooms.

For the Steering Gear.

For each size of steering gear motor and motor-generator, if no standby machine is installed, the following spare gear is required in addition to the spares for motors enumerated above.

1 spare armature of each size fitted, complete with shaft and half coupling.
1 spare field coil of each type fitted.
Where electric steering gear is fitted and there is no standby generator, similar spare gear is also to be provided for the generator.

For the Control Gear.

For the starting gear of motors, such as those enumerated above :—

1 set of contacts subject to burning or wear.
1 set of springs.

10 per cent of each different resistance element, but at least one of each.

1 of each type of coil used for contactors, relays or low voltage release.

For six or less starters in which these parts are interchangeable it will be sufficient to provide one set of spares for the starter employing the greatest number of parts.

For the Switchgear and Distribution Boards.

For each type of circuit breaker on each pole :—

1 set of contacts which are liable to be burnt or worn.

1 set of parts subject to wear.

1 set of springs.

1 shunt trip coil and 1 resistance element, of each kind used.

10 per cent but not less than 12 of each type of cartridge or other non-rewireable fusible cut-out.

2 fuse-handles of each type and size used.

For the Navigating and Signal Lights, and their pilot lamps for indicating devices :—

1 complete spare set of lamps.

Emergency Lighting.

Where this is supplied from storage batteries of a voltage different from the ship's circuit :—

1 complete spare set of lamps.

Insulation Tester.

It is recommended that a 500 volt insulation tester be provided with all equipment of 100 kw. and above for the testing of insulation and tracing of faults and that all parts of the system be periodically tested and the results recorded.

PERIODICAL SURVEYS.

Section 19.—The periodical surveys of Electrical Equipment are detailed on page 114.

71, Fenchurch Street, London, E.C.3.
8th April, 1937.

FEES FOR THE INSPECTION OF THE INSTALLATION OF ELECTRICAL EQUIPMENT.

Section 20.—The following Scale of Fees has been adopted for the inspection of the installation of Electrical Equipment in the United Kingdom, including the inspection of machines during manufacture and testing where such is required by the Rules.

£1 per kilowatt for the first 15 kilowatts.

10s.	„	each kw. above	15	and up to	30	kilowatts.
5s.	„	„	30	„	50	„
2s.	„	„	50	„	200	„
1s.	„	„	200	„	500	„
6d.	„	„	500	kilowatts.		

Minimum fee £5.

(The scale is based on the aggregate kilowatts of the generators.)

In the case of Tugs with small installations not exceeding 6 kilowatts, the fee is to be £3.

FEES FOR THE SURVEY OF ELECTRICAL EQUIPMENT AT SPECIAL SURVEYS.

The following scale of fees has been adopted for the survey of Electrical Equipment at Special Surveys held at Ports in the United Kingdom, viz. :—

For the first 6 kilowatts	Nil.
Above 6 and up to 15 kilowatts	£1
„ 15 „ 25 „	£2
„ 25 „ 50 „	£3
„ 50 „ 100 „	£4
„ 100 „ 500 „	£6
„ 500 kilowatts	£7
Passenger vessels of 15,000 to 30,000 tons gross	£8
„ „ „ over 30,000 tons gross ...	£10

NOTE. The fees in the case of **Yachts** *to be increased by £1 in each of the above categories.*

Also, when damage repairs or re-arrangement of accommodation are necessary, additional fees should be charged.

71, Fenchurch Street, London, E.C.3.
25th April, 1935.

Table I.

Current-carrying Capacity (Subject to Voltage Drop) and Corresponding Fall of Pressure—Single Cables.

Nominal Area of Conductor.	Effective Area of Conductor.	Number and Diameter (in.) of Wires comprising Conductor.	Insulated with Rubber.		Insulated with Paper.		Insulated with Varnished Cambric.	
			Maximum Permissible Current.	Approx. Length (lead plus return) giving 1 volt drop with current (Col. 4).	Maximum Permissible Current.	Approx. Length (lead plus return) giving 1 volt drop with current (Col. 6).	Maximum Permissible Current.	Approx. Length (lead plus return) giving 1 volt drop with current (Col. 8).
1.	2.	3.	4.	5.	6.	7.	8.	9.
sq. in.	sq. in.		amps.	ft.	amps.	ft.	amps.	ft.
0·0010	0·00102	1/·036	4·1	30	4·1	30	—	—
0·0015	0·00152	1/·044	6·1	30	6·1	30	—	—
0·0020	0·00194	3/·029	7·8	30	7·8	30	—	—
0·0030	0·00299	3/·036	12·0	29	12·0	29	10·8	35
0·0030	0·00322	1/·064	12·9	29	12·9	29	11·6	35
0·0045	0·00455	7/·029	18·2	28	18·2	28	16·4	35
0·0070	0·00701	7/·036	24·0	33	28·0	27	25·0	35
0·0100	0·01046	7/·044	31·0	39	42·0	27	38·0	34
0·0145	0·01462	7/·052	37·0	45	57·0	28	51·0	36
0·0225	0·02214	7/·064	46·0	55	75·0	32	68·0	41
0·0300	0·02840	19/·044	53·0	61	87·0	35	78·0	45
0·0400	0·03960	19/·052	64·0	71	104·0	41	94·0	53
0·0600	0·06000	19/·064	83·0	83	135·0	48	122·0	62
0·0750	0·07592	19/·072	97·0	90	157·0	52	141·0	68
0·1000	0·10090	19/·083	118·0	98	191·0	57	172·0	73
0·1200	0·11680	37/·064	130·0	103	210·0	60	189·0	78
0·1500	0·14780	37/·072	152·0	112	246·0	65	222·0	83
0·2000	0·19640	37/·083	184·0	123	296·0	72	266·0	92
0·2500	0·24650	37/·093	214·0	132	343·0	78	309·0	100
0·3000	0·30240	37/·103	240·0	145	385·0	85	346·0	109
0·4000	0·40640	61/·093	288·0	162	464·0	95	417·0	122
0·5000	0·49850	61/·103	332·0	172	540·0	100	486·0	128
0·6000	0·60620	91/·093	384·0	181	624·0	105	561·0	135
0·7500	0·74350	91/·103	461·0	185	738·0	109	664·0	140
0·8500	0·84590	127/·093	512·0	190	815·0	116	733·0	144
1·0000	1·03760	127/·103	595·0	200	932·0	121	839·0	152

Table II.

Twin Flexible Cords and Cables. Current-carrying Capacity and Corresponding Fall of Pressure.

Nominal Area of Conductor.	Composition of Strand.	Maximum Current Permissible (subject to voltage drop).	Approximate length (lead plus return) giving 1 volt drop with current (Col. 3).
1.	2.	3.	4.
sq. in.	No. and diam. in.	amps.	feet.
0·0006	14/0·0076	1·8	59
0·001	23/0·0076	3·0	59
0·0017	40/0·0076	5·0	57
0·003	70/0·0076	8·5	57
0·0048	110/0·0076	13·0	56
0·007	162/0·0076	17·0	69

Table III.

Intermittent Working. Current-carrying Capacity for Single Cables.

Nominal Area of Conductor	Insulated with Rubber.			Insulated with Paper.			Insulated with Varnished Cambric.		
	Half-hour Rating.	One hour Rating.	Continuous Rating as in Table I	Half-hour Rating.	One hour Rating.	Continuous Rating as in Table I	Half-hour Rating.	One hour Rating.	Continuous Rating as in Table I
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
sq. in.	amps.	amps.	amps.	amps.	amps.	amps.	amps.	amps.	amps.
0·0145	38	37	37	60	57	57	54	51	51
0·0225	47	46	46	79	75	75	71	68	68
0·03	56	54	53	94	89	87	84	80	78
0·04	68	65	64	113	105	104	102	95	94
0·06	92	85	83	151	138	135	136	124	122
0·075	113	101	97	180	162	157	162	146	141
0·1	142	124	118	225	199	191	203	179	172
0·12	160	138	130	252	220	210	226	198	189
0·15	191	164	152	303	261	246	273	235	222
0·2	247	204	184	376	320	296	338	288	266
0·25	295	244	214	453	377	343	407	340	309
0·3	351	283	240	523	435	385	470	392	346
0·4	452	357	288	663	543	464	596	488	417
0·5	534	422	332	804	648	540	723	584	486
0·6	641	499	384	960	767	624	864	690	561
0·75	774	604	461	1,180	930	738	1,061	838	664
0·85	900	680	512	1,325	1,045	815	1,190	940	733
1·0	1,036	803	595	1,548	1,211	932	1,390	1,090	839

Table IV.

Dimensions of Single Core Cables—Rubber Insulated.

For pressures not varying from the potential of the ship's hull by more than 250 volts.

Conductors.		Dielectric.	Braided Cables.	Braided and Armoured Cables.			Lead-covered Cables.		Lead-covered and Armoured Cables.		
Nominal Area.	Overall Diam.	Minimum Thickness.	Overall Diam.	Diam. of Armouring Wire.	Diam. over Armour.	Diam. over Armour and Braiding.	Minimum Thickness of Lead.	Diam. over Lead.	Diam. of Armouring Wire.	Diam. over Armour.	Diam. over Armour and Braiding.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
sq. in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
0·0010	0·036	0·034	0·165	0·064	0·328	0·418	0·040	0·200	0·064	0·408	0·498
0·0015	0·044	0·034	0·173	0·064	0·336	0·426	0·040	0·208	0·064	0·416	0·506
0·0020	0·063	0·036	0·195	0·064	0·358	0·448	0·040	0·230	0·064	0·438	0·528
0·0030	0·078	0·038	0·215	0·064	0·378	0·468	0·040	0·250	0·064	0·458	0·548
0·0030	0·064	0·036	0·197	0·064	0·360	0·450	0·040	0·232	0·064	0·440	0·530
0·0045	0·087	0·039	0·226	0·064	0·389	0·479	0·040	0·261	0·064	0·469	0·559
0·0070	0·108	0·041	0·259	0·064	0·422	0·512	0·050	0·314	0·064	0·522	0·612
0·0100	0·132	0·043	0·287	0·064	0·450	0·540	0·050	0·342	0·064	0·550	0·640
0·0145	0·156	0·046	0·317	0·064	0·480	0·570	0·060	0·392	0·064	0·600	0·690
0·0225	0·192	0·049	0·359	0·064	0·522	0·612	0·060	0·434	0·072	0·698	0·788
0·0300	0·220	0·052	0·393	0·064	0·556	0·646	0·060	0·468	0·072	0·732	0·822
0·0400	0·260	0·056	0·441	0·064	0·604	0·694	0·060	0·516	0·072	0·780	0·870
0·0600	0·320	0·062	0·513	0·072	0·732	0·822	0·070	0·608	0·072	0·872	0·962
0·0750	0·360	0·066	0·596	0·072	0·780	0·870	0·070	0·656	0·072	0·920	1·010
0·1000	0·415	0·072	0·663	0·072	0·847	0·937	0·070	0·723	0·072	0·987	1·077
0·1200	0·448	0·075	0·702	0·072	0·886	0·976	0·070	0·762	0·072	1·026	1·146
0·1500	0·504	0·080	0·768	0·072	0·952	1·042	0·080	0·848	0·080	1·208	1·328
0·2000	0·581	0·088	0·889	0·072	1·053	1·173	0·080	0·949	0·080	1·309	1·429
0·2500	0·651	0·095	0·973	0·080	1·233	1·353	0·090	1·053	0·104	1·461	1·581
0·3000	0·721	0·102	1·057	0·080	1·317	1·437	0·090	1·137	0·104	1·545	1·665
0·4000	0·837	0·114	1·197	0·104	1·505	1·625	0·100	1·297	0·104	1·705	1·825
0·5000	0·927	0·121	1·301	0·104	1·609	1·729	0·110	1·421	0·128	1·877	1·997
0·6000	1·023	0·125	1·425	0·128	1·761	1·881	0·110	1·525	0·128	1·981	2·101
0·7500	1·133	0·131	1·547	0·128	1·883	2·003	0·120	1·667	0·160	2·187	2·307
0·8500	1·209	0·135	1·631	0·128	1·967	2·087	0·120	1·751	0·160	2·271	2·391
1·0000	1·339	0·141	1·773	0·128	2·173	2·293	0·120	1·893	0·160	2·413	2·533

TABLE V.—DIMENSIONS OF CABLES—1,000 VOLT PAPER INSULATED OR VARNISHED CAMBRIC INSULATED.

Conductors.		Dielectric.	Single-core Lead Covered Cables.		Single-core Lead-covered and Armoured Cables (Single-wire Armouring).	
Nominal Area.	Overall Diameter.	Minimum Thickness.	Minimum Thickness of Lead.	Diameter over Lead.	Diameter of armouring wire.	Diameter over Armour.
1.	2.	3.	4.	5.	6.	7.
sq. in.	in.	in.	in.	in.	in.	in.
0·0015	0·044	0·07	0·06	0·304	0·064	0·552
0·0020	0·063	0·07	0·06	0·323	0·064	0·571
0·0030	0·078	0·07	0·06	0·338	0·064	0·586
0·0030	0·064	0·07	0·06	0·324	0·064	0·572
0·0045	0·087	0·07	0·06	0·347	0·064	0·595
0·0070	0·108	0·07	0·06	0·368	0·064	0·616
0·0100	0·132	0·07	0·06	0·392	0·064	0·640
0·0145	0·156	0·07	0·06	0·416	0·072	0·68
0·0225	0·192	0·07	0·06	0·452	0·072	0·716
0·0300	0·220	0·07	0·06	0·48	0·072	0·744
0·0400	0·260	0·07	0·06	0·52	0·072	0·784
0·0600	0·320	0·07	0·06	0·58	0·072	0·844
0·0750	0·360	0·07	0·06	0·62	0·072	0·884
0·1000	0·415	0·07	0·06	0·675	0·072	0·939
0·1200	0·448	0·07	0·06	0·708	0·072	1·972
0·1500	0·504	0·07	0·07	0·784	0·072	1·048
0·2000	0·581	0·07	0·07	0·861	0·080	1·221
0·2500	0·651	0·08	0·07	0·951	0·080	1·311
0·3000	0·721	0·08	0·08	1·041	0·080	1·401
0·4000	0·837	0·09	0·08	1·177	0·104	1·585
0·5000	0·927	0·09	0·08	1·267	0·104	1·675
0·6000	1·023	0·09	0·09	1·383	0·128	1·839
0·7500	1·133	0·10	0·09	1·513	0·128	1·969
0·8500	1·209	0·10	0·10	1·609	0·128	2·065
1·0000	1·339	0·10	0·10	1·739	0·128	2·195

TABLE VI.—SIZES OF GALVANIZED STEEL WIRES AND THICKNESSES OF BEDDING FOR SINGLE WIRE ARMOURING.

Diameter of Cable to be Armoured, exclusive of Bedding.		Diameter of Galvanized Steel Wire.	Thickness of Bedding.	Type of Bedding to be used.
Above.	Up to and including.			
1.	2.	3.	4.	5.
in.	in.	in.	in.	
—	0·4	0·064	0·04	Two coats of hessian tape.
0·4	0·8	0·072	0·06	Two coats of hessian tape or two coats of jute yarn.
0·8	1·05	0·08	0·1	Three coats of hessian tape or two coats of jute yarn.
1·05	1·3	0·104	0·1	
1·3	3·5	0·128	0·1	
3·5	—	0·16	0·1	

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Table VII.

Insulation Resistance of Rubber Insulated Cables.

Nominal Area of Cable.	Minimum Insulation Resistence.			
	Megohms for a 1,000 yard length at 60° F. (15·6° C.) 600-megohm Grade.	Megohms for a mile length at 60° F. (15·6° C.) 500-megohm Grade.	Megohms for a 1,000 yard length at 60° F. (15·6° C.) 2,500-megohm Grade.	Megohms for a mile length at 60° F. (15·6° C.) 2,500-meghom Grade.
sq. in.				
0·0010	3,520	2,000	8,800	5,000
0·0015	3,520	2,000	8,800	5,000
0·0020	2,200	1,250	7,920	4,500
0·0030	2,200	1,250	7,920	4,500
0·0030	3,520	2,000	8,800	5,000
0·0045	2,200	1,250	7,920	4,500
0·0070	1,584	900	7,040	4,000
0·0100	1,584	900	7,040	4,000
0·0145	1,584	900	7,040	4,000
0·0225	1,584	900	6,160	3,500
0·0300	1,320	750	6,160	3,500
0·0400	1,320	750	5,280	3,000
0·0600	1,320	750	5,280	3,000
0·0750	1,056	600	5,280	3,000
0·1000	1,056	600	5,280	3,000
0·1200	1,056	600	5,280	3,000
0·1500	1.056	600	5,280	3,000
0·2000	1,056	600	4,400	2,500
0·2500	1,056	600	4,400	2,500
0·3000	1,056	600	4,400	2,500
0·4000	1,056	600	4,400	2,500
0·5000	1,056	600	4,400	2,500
0·6000	1,056	600	4,400	2,500
0·7500	1,056	600	4,400	2,500
0·8500	1,056	600	4,400	2,500
1·0000	1,056	600	4,400	2,500

Table VIII.

Maximum Spacing of Clips securing Lead-covered or Armoured Cables.

Overall Diameter of Cable.	Lead-covered.	Armoured.
	Inches.	Inches.
Under 0·3 inch	8	10
0·3 inch and under 0·5 inch ...	10	12
0·5 „ „ 0·75 „ ...	12	14
0·75 „ „ 1·25 „ ...	14	16
1·25 inches and above	16	18

Lloyd's Register of Shipping, London.—24*th April*, 1930.

Table IX.

Approximate Fusing Currents of Wires in Free Air.

Diameter of Wire.	Equivalent S.W.G. Size.	Copper.		Lead-Tin Alloy. (Lead 75% Tin 25%.)	
		Fusing Current.	Maximum Safe Working Current.	Fusing Current.	Maximum Safe Working Current.
1.	2.	3.	4.	5.	6.
inch.		amperes.	amperes.		
0·0092	34	8·6	4·3	—	—
0·01	33	9·8	4·9	—	—
0·0108	32	11·0	5·5	—	—
0·012	—	12·8	6·4	—	—
0·0124	30	13·5	6·8	—	—
0·0148	28	17	8·6	—	—
0·018	26	22	11	—	—
0·02	25	—	—	3	2·0
0·022	24	30	15	3·5	2·3
0·024	23	—	—	4	2·6
0·028	22	41	21	5	3·3
0·032	21	—	—	6	4·1
0·029	—	43	22	—	—
0·036	20	62	31	7	4·8
0·04	19	73	37	—	—
0·044	—	86	43	—	—
0·048	18	98	49	10	7·0
0·052	—	111	56	—	—
0·056	17	125	63	—	—
0·064	16	156	78	16	11·0
0·072	15	191	96	—	—
0·08	14	229	115	—	—

Note.—The values given in the Tables may be taken to be correct where the fuse wire passes through an asbestos tube and does not closely touch the tube, but they do not apply where a substantial length of the wire is in contact with a porcelain holder.

Lloyd's Register of Shipping, London.—26*th October*, 1933.

Table X.

Dimensions of Tough Rubber Sheathed Cables and Thicknesses of Lead Sheathing for Multicore Rubber Insulated Cables.

For pressures not varying from the potential of the ship's hull by more than 250 volts. Thicknesses of Dielectric, Lead Sheathing and Tough Rubber Compound*.

Nominal Area of onductor.	Number and Diameter of Wires comprising Conductor.	D. Minimum Thickness of Dielectric.	Minimum Thickness of Tough Rubber Sheath.				Minimum Thickness of Lead.		
			Single.	Twin (Circular.)	Twin (Flat).	Three Core.	Concentric.	Twin (flat or round).	Three† Core.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
sq. in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
0·001	1/·036	0·034	0·05	0·05	0·05	0·05	0·04	0·04	0·05
0·0015	1/·044	0·034	0·05	0·05	0·05	0·05	0·04	0·04	0·05
0·002	3/·029	0·036	0·05	0·06	0·06	0·06	0·04	0·04	0·05
0·003	3/·036	0·038	0·05	0·06	0·06	0·06	0·04	0·04	0·05
0·003	1/·064	0·036	0·05	0·06	0·06	0·06	0·04	0·04	0·05
0·0045	7/·029	0·039	0·05	0·06	0·06	0·06	0·05	0·05	0·06
0·007	7/·036	0·041	0·05	0·06	0·06	0·06	0·05	0·05	0·06
0·01	7/·044	0·043	0·05	0·06	0·06	0·06	0·05	0·05	0·07
0·0145	7/·052	0·046	0·05	0·06	0·06	0·08	0·06	0·06	0·07
0·0225	7/·064	0·049	0·06	0·08	0·08	0·08	0·06	0·06	0·07
0·03	19/·044	0·052	0·06	0·08	0·08	0·08	0·07	0·07	0·08
0·04	19/·052	0·056	0·06	0·1	0·1	0·1	0·08	0·08	0·09
0·06	19/·064	0·062	0·06	0·1	0·1	0·1	0·08	0·08	0·09
0·075	19/·072	0·066	0·06	0·1	0·1	0·12	0·08	0·08	0·09
0·1	19/·083	0·072	0·08	0·12	0·12	0·12	0·09	0·09	0·1
0·12	37/·064	0·075	0·08	0·12	0·12	0·13	0·09	0·09	0·1
0·15	37/·072	0·08	0·08	0·13	0·13	0·13	0·09	0·09	0·1
0·2	37/·083	0·088	0·1	0·15	0·15	0·15	0·1	0·1	0·11
0·25	37/·093	0·095	0·1	0·15	—	0·175	0·11	0·11	0·12
0·3	37/·103	0·102	0·1	0·175	—	0·175	0·12	0·12	0·13
0·4	61/·093	0·114	0·12	0·2	—	0·225	0·13	0·13	0·14
0·5	61/·103	0·121	0·12	0·225	—	0·25	0·14	0·14	0·15
0·6	91/·093	0·125	0·13	0·25	—	0·25	—	—	—
0·75	91/·103	0·131	0·13	0·25	—	0·25	—	—	—
0·85	127/·093	0·135	0·13	0·25	—	0·25	—	—	—
1·0	127/·103	0·141	0·15	0·25	—	0·25	—	—	—

*Thicknesses of Tapes and Braids are not included.

†The thickness of lead on Multicore Cables in the case where the Conductors are not of equal area is to be the same as the thickness of lead in a similar Cable having all Conductors of the same area as that of the largest Conductor in the Cable where the Conductors are unequal.

D is the thickness of the dielectric as follows:—

(1) On the Conductor of single Conductor Cables.

(2) On each Conductor of Concentric Cables.

(3) On each core of Twin and Three-Core Cables.

Lloyd's Register of Shipping, London.—21*st June*, 1934.

Table XI.

Dimensions of 660 Volt Cables—Rubber Insulated.

For pressures not varying from the potential of the ship's hull by more than 660 volts.

Thicknesses of dielectric, lead sheathing and tough rubber compound.*

Nominal Area of Conductor.	Number and Diameter of Wires comprising Conductor.	D. Minimum Thickness of Dielectric	Minimum Thickness of Lead.				Minimum Thickness of Tough Rubber Compound.			
			Single.	Concentric.	Twin.	Three† Core.	Single.	Twin (Circular)	Twin (Flat).	Three Core.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
sq. in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
0·001	1/·036	0.055	0·05	0·05	0·05	0·06	0·05	0·06	0·06	0·06
0·0015	1/·044	0·055	0·05	0·05	0·05	0·06	0·05	0·06	0·06	0·06
0·002	3/·029	0·056	0·05	0·05	0·05	0·06	0·05	0·06	0·06	0·06
0·003	3/·036	0·057	0·05	0·05	0·05	0·06	0·05	0·06	0·06	0·06
0·003	1/·064	0·057	0·05	0·05	0·05	0·06	0·05	0·06	0·06	0·06
0·0045	7/·029	0·058	0·05	0·06	0·06	0·07	0·05	0·06	0·06	0·06
0·007	7/·036	0·059	0·06	0·06	0·06	0·07	0·05	0·06	0·06	0·06
0·01	7/·044	0·060	0·06	0·06	0·06	0·08	0·06	0·08	0·08	0·08
0·0145	7/·052	0·061	0·06	0·07	0·07	0·08	0·06	0·08	0·08	0·08
0·0225	7/·064	0·062	0·06	0·07	0·07	0·08	0·06	0·08	0·08	0·08
0·03	19/·044	0·062	0·06	0·07	0·07	0·08	0·06	0·08	0·08	0·08
0·04	19/·052	0·063	0·06	0·08	0·08	0·09	0·06	0·1	0·1	0·1
0·06	19/·064	0·065	0·07	0·08	0·08	0·09	0·06	0·1	0·1	0·1
0·075	19/·072	0·066	0·07	0·08	0·08	0·09	0·06	0·1	0·1	0·12
0·1	19/·083	0·072	0·07	0·09	0·09	0·1	0·08	0·12	0·12	0·12
0·12	37/·064	0·075	0·07	0·09	0·09	0·1	0·08	0·12	0·12	0·13
0·15	37/·072	0·080	0·08	0·09	0·09	0·1	0·08	0·13	0·13	0·13
0·2	37/·083	0·088	0·08	0·1	0·1	0·11	0·1	0·15	0·15	0·15
0·25	37/·093	0·095	0·09	0·11	0·11	0·12	0·1	0·15	—	0·175
0·3	37/·103	0·102	0·09	0·12	0·12	0·13	0·1	0·175	—	0·175
0·4	61/·093	0·114	0·1	0·13	0·13	0·14	0·12	0·2	—	0·225
0·5	61/·103	0·121	0·11	0·14	0·14	0·15	0·12	0·225	—	0·25
0·6	91/·093	0·125	0·11	—	—	—	0·13	0·25	—	0·25
0·75	91/·103	0·131	0·12	—	—	—	0·13	0·25	—	0·25
0·85	127/·093	0·135	0·12	—	—	—	0·13	0·25	—	0·25
1·0	127/·103	0·141	0·12	—	—	—	0·15	0·25	—	0·25

*Thicknesses of Tapes and Braids are not included.

†The thickness of lead on Multicore Cables in the case where the Conductors are not of equal area is to be the same as the thickness of lead in a similar Cable having all Conductors of the same area as that of the largest Conductor in the Cable where the Conductors are unequal.

D is the thickness of the dielectric as follows :—

(1) On the Conductor of single Conductor Cables.

(2) On each Conductor of Concentric Cables.

(3) On each core of Twin and Three-Core Cables.

Table XII.

Dimensions of Multi-Core Cables—Paper Insulated or Varnished Cambric Insulated.

Thicknesses of Dielectric and Lead Sheath.

For pressures not varying from the potential of the ship's hull by more than 1,000 volts.

Nominal Area of Conductor.	Number and Diameter of Wires comprising Conductor.	D. Minimum Thickness of Dielectric.	Minimum Thickness of Lead.					
			Twin.		Three Core.		Four Core.	
			Circular Conductors.	Shaped Conductors.	Circular Conductors.	Shaped Conductors.	Circular Conductors.	Shaped Conductors.
1	2.	3.	4.	5.	6.	7.	8.	9.
sq. in.	in.	in.	in.	in.	in.	in.	in.	in.
0·007	7/·036	0·07	0·06	—	0·06	—	0·06	—
0·01	7/·044	0·07	0·06	—	0·06	—	0·06	—
0·0145	7/·052	0·07	0·06	0·06	0·06	—	0·06	—
0·0225	7/·064	0·07	0·06	0·06	0·06	0·06	0·06	0·06
0·03	19/·044	0·07	0·06	0·06	0·06	0·06	0·06	0·06
0·04	19/·052	0·07	0·06	0·06	0·06	0·06	0·07	0·06
0·06	19/·064	0·07	0·07	0·06	0·07	0·06	0·07	0·07
0·075	19/·072	0·07	0·07	0·06	0·07	0·06	0·08	0·07
0·1	19/·083	0·07	0·07	0·06	0·08	0·07	0·08	0·08
0·12	37/·064	0·07	0·08	0·06	0·08	0·07	0·08	0·08
0·15	37/·072	0·07	0·08	0·07	0·08	0·07	0·09	0·08
0·2	37/·083	0·07	0·09	0·07	0·09	0·08	0·10	0·09
0·25	37/·093	0·08	0·09	0·08	0·10	0·09	0·10	0·10
0·3	37/·103	0·08	0·10	0·08	0·10	0·09	0·11	0·10
0·4	61/·093	0·09	0·11	0·09	0·11	0·10	0·12	0·11
0·5	61/·103	0·09	0·12	0·09	0·12	0·10	0·13	0·12
0·6	91/·093	0·09	0·12	0·10	0·13	0·12	0·14	0·13
0·75	91/·103	0·10	0·13	0·11	0·14	0·13	0·15	0·14
0·85	127/·093	0·10	0·14	0·12	0·15	0·13	0·16	0·15
1·0	127/·103	0·10	0·15	0·13	0·15	0·14	0·17	0·16

D is the thickness of dielectric between any one Conductor and the next Conductor or the Lead Sheath.

The thickness of sheath on Multi-Core Cables in the case where the Conductors are *not of equal area* is to be the same as the thickness of sheath in a similar Cable having all Conductors of the same area as that of the largest Conductor in the Cable.

Table XIII.

Dimensions of 3,300 Volt Paper Insulated or Varnished Cambric Insulated Cables.

Thicknesses of Dielectric and Lead Sheath.

Nominal Area of Conductor.	D. Minimum Thickness of Dielectric.	Minimum Thickness of Lead.					
		Single Core.	Concentric.	Twin.		Three Core.	
				Circular Conductors.	Shaped Conductors.	Circular Conductors.	Shaped Conductors.
1.	2.	3.	4.	5.	6.	7.	8.
sq. in.	in.	in.	in.	in.	in.	in.	in.
0·0225	0·11	0·06	0·06	0·06	0·06	0·06	0·06
0·03	0·11	0·06	0·06	0·06	0·06	0·06	0·06
0·04	0·11	0·06	0·06	0·07	0·06	0·07	0·06
0·06	0·11	0·06	0·07	0·07	0·06	0·07	0·07
0·075	0·11	0·06	0·07	0·07	0·07	0·08	0·07
0·1	0·11	0·07	0·07	0·08	0·07	0·08	0·07
0·15	0·11	0·07	0·08	0·08	0·07	0·09	0·08
0·2	0·11	0·07	0·08	0·09	0·08	0·09	0·08
0·25	0·11	0·08	0·08	0·1	0·08	0·1	0·09
0·3	0·11	0·08	0·09	0·1	0·08	0·11	0·09
0·4	0·12	0·08	0·09	0·11	0·09	0·12	0·1
0·5	0·13	0·09	0·1	0·12	0·1	0·13	0·11
0·6	0·14	0·09	—	—	—	—	—
0·75	0·15	0·1	—	—	—	—	—

D is the thickness of the dielectric as follows :—

(1) Single-Core Cables: Between the Conductor and Lead Sheath.

(2) Concentric Cables: Between the Conductors and between the outer Conductor and Lead Sheath.

(3) Twin Cables: Between the Conductors and between any Conductor and Lead Sheath.

(4) Three-Core Cables: Between the Conductors and between any Conductor and Lead Sheath.

Lloyd's Register of Shipping, London.—21*st June*, 1934.

APPENDICES Nos. 1, 2, 3 AND 4 IN CONNECTION WITH THE RULES FOR ELECTRICAL EQUIPMENT AND ELECTRIC PROPELLING MACHINERY.

APPENDIX 1.

BUS-BARS AND CONNECTIONS.

1. **Material.**—The metal used is to be in accordance with the following requirements :—

(*a*) COPPER. The conductivity of annealed copper is to be not less than 99·25 per cent, and medium hard and hard copper not less than 95 per cent of that standardised by the International Electrotechnical Commission (Publication No. 28).

(*b*) ALUMINIUM. The conductivity of aluminium is to be not less than 60 per cent of that standardised by the International Electrotechnical Commission for annealed copper.

The metal is to have a bright, smooth finish free from seams, cracks and other imperfections.

2. **Joints.**—All joints between copper conductors are to be made after tinning or coating with petroleum jelly, or have equally effective treatment for preventing deterioration of the joint.

All joints between aluminium conductors are to be made after the surfaces have been lightly coated with petroleum jelly and then scratch brushed, the joints being clamped

together with the petroleum jelly still in position, or to have equally effective treatment for preventing deterioration of the joint.

In the case of joints between copper and aluminium, provision is to be made for the prevention of electrolytic action which takes place between the two metals in contact in the presence of moisture, either by the exclusion of moisture from the joint, or by the introduction of a suitable bi-metallic connector or its equivalent.

All joints, whether soldered or not, are to have the parts mechanically secured together.

3. **Limits of Temperature.**—The following temperature limitations measured by thermometer, are to apply to bare conductors in contact with air, when carrying their rated current continuously :—

CONDUCTORS RATED 2,000 AMPS. AND BELOW :—
Maximum temperature 70° C. (158° F.).

CONDUCTORS RATED ABOVE 2,000 AMPS. :—
Maximum temperature 80° C. (176° F.).

NOTE :—See also **Section 3, clause 2** (*i*) of the **Rules for Electrical Equipment** and **Section 8, clause 2** (*f*) of the **Rules for Electric Propelling Machinery.**

4. **Thermal Expansion.**—Where necessary, provision is to be made to allow for expansion and contraction due to temperature variations.

5. **Clearance Distances.**—The clearance distances specified below apply only to bus-bars having no insulation covering other than the surrounding air, compound or oil.

Bus-bars and their connections are to be spaced in accordance with the following clearance distances :—

Max. Rated Voltage between Phases or Poles.	Minimum Clearance to Earth.		Minimum Clearance between Phases or Poles.	
	In Air.	In Oil or Compound.	In Air.	In Oil or Compound.
	inches.	inches.	inches.	inches.
660	$\frac{5}{8}$	—	$\frac{3}{4}$	—
2,200	$1\frac{1}{2}$	—	$1\frac{1}{2}$	—
3,300	2	$\frac{1}{2}$	2	$\frac{3}{4}$
6,600	$2\frac{1}{2}$	$\frac{3}{4}$	$3\frac{1}{2}$	1

IMPORTANT NOTE:—The above figures do not apply to creepage distance along the surface of insulators or of insulating bases.

6. **Mechanical Strength.**—The bus-bars and connections are to be so proportioned and supported as to be capable of safely withstanding the maximum mechanical stresses to which they may be subjected by the initial value of the short circuit current.

APPENDIX 2.

MOTORS AND GENERATORS FOR AUXILIARY PURPOSES.

1. **Classes of Rating.**—(*a*) CONTINUOUS RATING. The rating which can be carried on test for an unlimited period without exceeding the limits of temperature rise as given in **clause 3.**

(*b*) SHORT TIME RATING. The load which can be carried on test for the time specified in the rating without exceeding the limits of temperature as given in **clause 3,**

starting with the machine cold. Two standard ratings are recognised, viz.:—One-hour rating and one half-hour rating.

2. **Insulating Materials.**—The following International Electrotechnical Commission Classifications are adopted as standard.

Class A. Cotton, silk, paper and similar organic materials when impregnated or immersed in oil, also enamelled wire.

Class B. Mica and asbestos and similar inorganic materials in built up form combined with binding cement. If Class A material is used in small quantities for structural purposes only in conjunction with Class B insulation, the combined materials may be considered as Class B, provided the electrical and mechanical properties of the insulated winding are not impaired by the application of the temperature permitted for Class B material.

3. **Limits of Temperature Rise.**—The temperature rise measured by thermometer when tested under rated conditions is not to exceed the following limits:—

Part of Machine.	Temperature Rise.	
	Machines other than Totally Enclosed.	Totally Enclosed Machines.
1. Windings insulated with Class A material and cores with which they are in contact	72° F.(40° C.)	90° F.(50° C.)
2. Commutators	81° F.(45° C.)	99° F.(55° C.)
3. Slip Rings—open type...	81° F.(45° C.)	99° F.(55° C.)
enclosed ...	99° F.(55° C.)	99° F.(55° C.)

The temperature rise of uninsulated parts including cores not in contact with insulated windings is in no case to reach such a value that there is a risk of injury to any insulating material on adjacent parts.

The standard ratings are suitable for machines working with a temperature of cooling air not exceeding 40° C. For machines in hot situations or tropical climates *see* **Section 2, clause 1** and **Section 11, clause 2** of the **Rules for Electrical Equipment.**

4. **Overloads and Excess Current and Torque.**— Motors and generators are to be capable of carrying, without injury, the following sustained overloads after having attained the temperature rise corresponding to their rated load, the voltage and frequency being maintained at their rated values :—

Motors with continuous rating (not totally enclosed) are to withstand the following overloads in torque :—

Sizes 10 H.P. and upwards per 1,000 r.p.m.	25 per cent for 2 hours.
Sizes 4 H.P. per 1,000 r.p.m. up to 10 H.P. per 1,000 r.p.m.	25 per cent for half-hour.
Sizes below 4 H.P. per 1,000 r.p.m.	25 per cent for 15 minutes.
All sizes (including totally enclosed)	50 per cent for 1 minute.
D.C. motors up to 150 H.P. per 1,000 r.p.m. ...	100 per cent for 15 seconds.
A.C. motors of all sizes ...	100 per cent for 15 seconds

MOTORS WITH SHORT TIME RATING including totally enclosed motors:—

All sizes ... ...100 per cent for 30 seconds.

Machines with short time ratings and all totally enclosed machines are not required to carry sustained overloads.

GENERATORS with continuous rating (not totally enclosed) are to carry the following overloads in current at full-rated volts:—

Sizes $7\frac{1}{2}$ k.v.a. and upwards per 1,000 r.p.m. ... ... 25 per cent for 2 hours.

Sizes 3 k.v.a. to $7\frac{1}{2}$ k.v.a. per 1,000 r.p.m. ... ... 25 per cent for half-hour.

Sizes below 3 k.v.a. per 1,000 r.p.m. ... ... 25 per cent for 15 minutes.

All sizes, including totally enclosed generators, 50 per cent for one minute.

NOTE.—k.v.a.=k.w. for direct current machines.

5. **Commutation.**—A D.C. machine is to work with fixed brush setting from no load to the momentary excess current or torque specified, and is to work sparklessly and without injury to the surface of the commutator or brushes from no load to the rated load, and without injurious sparking or injury to the commutator or brushes up to the momentary (one minute or less) excess current or torque specified.

The commutation test is to be applied at the conclusion of the temperature test.

6. **High Voltage (Dielectric) Tests.**—The high voltage test is to be applied only to new and completed machines in normal working condition with all its parts in place, at the

makers' works, preferably at the conclusion of the temperature test. It will be applied between the windings and the frame with the core connected to the frame, and to any windings not under test.

The full test voltage is to be maintained for one minute, and is to be made with alternating voltage of any convenient frequency between 25 and 100 cycles per second.

Machine or Part.	Test Voltage.
1. Machines under 3 B.H.P., k.w., or k.v.a.	1,000 v. + twice the rated voltage.
2. Machines 3 B.H.P., k.w., or k.v.a. and over.	1,000 v. + twice the rated voltage, with a minimum of 2,000 v.
3. Field windings of synchronous generators.	10 times the excitation voltage: Minimum ...2,000 v. Maximum...3,500 v.
4. Exciter	Not less than that applied to the field windings of the machine to which it is connected.
5. Induction motor rotor windings. not permanently short circuited.	For non-reversing motors 1,000 v. + twice the maximum voltage which could be induced between the slip rings.

7. **Insulation Resistance.**—The insulation resistance in megohms when the high voltage test is applied is to be not less than

$$\frac{\text{rated volts}}{1{,}000 + \text{rated output in k.v.a. or B.H.P.}}$$

The insulation resistance is to be measured with a D.C. voltage of about 500.

8. **Performance Tests.**—Tests are to be carried out at the makers' works to ensure that the machine complies with the requirements in respect to limits of temperature rise, excess current and torque, commutation and high voltage tests.

In the case of generators up to 50 k.v.a. per 1,000 r.p.m. type tests of temperature rise, excess current and torque and commutation taken on a machine identical in

rating and all other essential details may be accepted, in conjunction with abbreviated tests on each individual machine.

For the abbreviated test each machine is to be run and is to be found electrically and mechanically sound and in working order in all particulars, and is to have a high voltage (dielectric) test.

The temperature test may be carried out at any convenient air temperature, and no correction should be made in the observed temperature rise in those cases where the temperature of the cooling air during the test is different from that expected in service. The temperature test for continuous rated machines is to continue until there is sufficient evidence that the temperature rise would not exceed the specified limits if the test were prolonged.

9. **Temperature Measurements.**—The temperatures are to be measured by thermometers applied to the hottest accessible surfaces during the test period, and other thermometers to the accessible surfaces of the rotating parts as soon as the machine is stopped after the test. The bulb of the thermometer, except at the point of contact, is to be covered with a pad of felt, cotton-wool or other non-conducting material, $\frac{1}{8}$ inch thick, extending at least $\frac{3}{4}$ inch in every other direction from the bulb, and pressed into contact to prevent loss of heat by radiation and convection from the bulb.

The temperature of the cooling air is to be the mean of several thermometers at different points around and half-way up the machine, and at distances of three to six feet away from it.

APPENDIX 3.

ALTERNATORS, MOTORS AND DIRECT CURRENT GENERATORS FOR ELECTRIC PROPULSION PURPOSES.

1. **Rating.**—The continuous maximum rating is the load which can be carried on test for an unlimited period without exceeding the specified limits of temperature rise.

2. **Insulating Materials.**—The following International Electrotechnical Commission Classifications are adopted as standard.

CLASS A. cotton, silk, paper and similar organic materials when impregnated or immersed in oil, also enamelled wire.

CLASS B. Mica and asbestos and similar inorganic materials in built up form combined with binding cement. If Class A material is used in small quantities for structural purposes only in conjunction with Class B insulation, the combined materials may be considered as Class B, provided the electrical and mechanical properties of the insulated winding are not impaired by the application of the temperature permitted for Class B material.

3. **Limits of Temperature Rise.**—(*a*) METHODS OF MEASUREMENT. The method to be used in any particular case is stated in **clauses** (*b*), (*c*) and (*d*) below.

(*b*) EMBEDDED TEMPERATURE DETECTORS. (E.T.D.) This is to be employed for the slot portion of the stator windings of alternators having a rated output of 5,000 k.v.a. or over, alternating current motors of 5,000 S.H.P. or over, or machines of either type having an axial core length of one metre or over.

(*c*) THERMOMETERS. This method is applicable to alternating current windings, where neither the E.T.D. method nor the resistance method is applicable, and to series

windings of low resistance, exciter windings and miscellaneous parts. Mercury or alcohol bulb thermometers are to be employed, the latter being used where the magnetic field alternates or rotates.

The temperatures are to be measured by thermometers applied to the hottest accessible surfaces during the test period and other thermometers to the accessible surfaces of the rotating parts as soon as the machine is stopped after the test. The bulb of the thermometer, except at the point of contact, is to be covered with a pad of felt, cotton-wool or other non-conducting material $\frac{1}{8}$ inch thick, extending at least $\frac{3}{4}$ inch in every other direction from the bulb and pressed into contact to prevent loss of heat by radiation and convection from the bulb.

(*d*) Resistance Method. The measurement of rise of temperature by increase of resistance method is applicable to all field windings (except stationary low resistance field windings and exciter field windings) and to stator windings not requiring the use of E.T.Ds. It is not to be used for alternating current windings of machines requiring more than five minutes to come to rest.

Resistance measurements are to be made before and during the temperature test.

(*e*) Limits of Temperature Rise Permissible. The temperature rise of any main propelling machine is not to exceed the limits given in **Table I.** of this appendix when tested at the continuous maximum rating for a duration sufficient to show that the temperature rise would not exceed the specified limits if the test were prolonged. When a machine has more than one rating, the test is to be carried out at the rating which produces the greatest temperature rise. In cases where this cannot be determined beforehand, the machine is to be tested separately under each of its ratings.

(*f*) TEMPERATURE OF COOLING AIR. The temperature of cooling air for open type machines is to be the mean of several thermometers at different points around and half-way up the machine and at distances of three to six feet away from it.

TABLE I.

LIMITS OF PERMISSIBLE TEMPERATURE RISE.

ITEM.	PART OF MACHINE.	CLASS A MATERIAL.		CLASS B MATERIAL.			
						By E.T.D.	
		By Thermometer method. 1	By Resistance method. 2	By Thermometer method. 3	By Resistance method. 4	(*a*) (see below.) 5	(*b*) (note below.) 6
1.	A.C. windings of stators or rotors.	81° F. (45° C.)	90° F. (50° C.)	99° F. (55° C.)	126° F. (70° C.)	126° F. (70°C)	108°F. (60°C)
2.	Field windings (other than 3, 4 & 5).	*	90° F. (50° C.)	*	126° F. (70° C.)	*	*
3.	Exciter windings	81° F. (45° C.)	*	99° F. (55° C.)	*	*	*
4.	Low resistance field windings of more than one layer, or compensating windings.	90° F. (50° C.)	*	108° F. (60° C.)	*	*	*
5.	Single layer field windings with exposed surface.	99° F. (55° C.)	99° F. (55° C.)	135° F. (75° C.)	135° F. (75° C.)	*	*
6.	Rotating field windings of turbine driven alternators.	*	90° F. (50° C.)	*	144° F. (80° C.)	*	*
7.	Short circuit windings insulated.	99° F. (55° C.)	*	135° F. (75° C.)	*	*	*
8.	Windings of armatures having commutators.	81° F. (45° C.)	*	99° F. (55° C.)	*	*	*
9.	Short circuited windings un-insulated.	The temperature rise of these parts is in no case to reach such a value that there is a risk of injury to any insulating or other material on adjacent parts.					
10.	Iron core and other parts not in contact with windings.						
11.	Iron core and other parts in contact with windings	The same limits of temperature rise as permitted for adjacent parts as given in Cols.1 and 3 (or 2 and 4 in the case of item 2).					
12.	Commutators	81° F. (45° C.).					
	Slip rings (open)	81° F. (45° C.).					
	Slip rings (enclosed) ...	90° F. (50° C.).					

(*a*) Between coils in one slot.
(*b*) Between outside of coil and bottom of slot.
* This method of measurement is not recognised in these cases.

4. **Excess Current and Torque.**—(*a*) Generators are to be capable of withstanding on test for 15 seconds a current in amperes 50 per cent in excess of their rated current, the voltage being maintained as near the rated output as possible consistent with the maximum capacity of the prime mover. The exact value of the voltage is not important.

(*b*) Direct current motors are to be capable of withstanding on test for 15 seconds a torque 50 per cent in excess of that corresponding to their rating, the voltage being maintained at rated value.

(*c*) Synchronous motors are to be capable of withstanding for 15 seconds without dropping out of synchronism a torque 50 per cent in excess of the torque corresponding to their rating, the voltage and frequency of the A.C. system with which they are synchronised being maintained at their rated values and the excitation of the motor being maintained at the value required to meet the specified conditions at rated load.

(*d*) Induction motors are to be capable of withstanding for 15 seconds without stalling a torque 50 per cent in excess of the torque corresponding to their rating, the voltage and frequency being maintained at their rated values.

5. **Commutation.**—Direct current machines are to work with fixed brush setting from no load to the excess current or torque specified and are to work practically sparklessly and without injury to the surface of the commutator or brushes from no load to the rated load and without injurious sparking or injury to the commutator or brushes up to the excess current or torque specified.

The commutation test is to be applied at the conclusion of the temperature test.

6. **High Voltage Tests.**—(*a*) The high voltage tests in accordance with **Table II.** of this appendix are to be applied only to new and completed machines in normal working

condition with all its parts in place and, unless otherwise agreed, are to be carried out at the makers' works, preferably at the conclusion of the temperature test.

(*b*) A high voltage test in accordance with **Table II.** is to be applied between the windings and the frame of the machine with the core connected to the frame and to any windings not under test.

The test voltage is to be based on the rated voltage.

In special cases of machines such as series connected machines, the test voltage is to be based on the rated voltage or the highest R.M.S. voltage reached between any part of the winding and the frame or between any two parts of the winding (whichever is the greatest).

(*c*) When for any reason it is considered necessary to make additional high voltage tests on a machine which has already passed its tests in accordance with **clause** (*b*) and is installed in the ship, the test voltage is to be 75 per cent of the value specified in **Table II.** Before the high voltage test is applied the windings are to be cleaned and the insulation resistance measured. The machine is to be thoroughly dried out before the application of the high voltage test if the insulation resistance in megohms is less than

$$\frac{\text{rated voltage}}{1{,}000 + \text{rated k.v.a.}}$$

(*d*) Method of Making High Voltage Test. The test is to be made with alternating voltage of approximately sine wave form of any convenient frequency between 25 and 100 periods per second. The R.M.S. value of the applied voltage is to be measured by a suitable voltmeter connected to the output side of the testing transformer, by means of a voltmeter used with a suitable calibrated potential transformer or by means of a voltmeter used in conjunction with a special calibrated voltmeter winding on the testing transformer.

(*e*) Duration of High Voltage Test. The test is to be commenced at a voltage of about one-third the test voltage

and increased to the test voltage as rapidly as is consistent with its value being indicated by the voltmeter. The full test voltage is then to be maintained for one minute, after which the test voltage is to be rapidly diminished to one-third its full value before switching off.

TABLE II.

ITEM.	HIGH VOLTAGE (DIELECTRIC) TESTS.	
	Machine or Parts.	Test Voltage (R.M.S.).
1.	Machines in general ...	1,000 v. + twice the rated voltage (with a minimum of 2,000 volts).
2.	Field windings for synchronous generators when the excitation voltage does not exceed 750 v.	10 times the excitation voltage: Minimum ...2,000 v. Maximum ...3,500 v.
3.	Field windings for synchronous motors started with the A.C. windings active:—	
	(*a*) when intended to be started up with the field windings short-circuited.	10 times the excitation voltage: Minimum ...2,000 v. Maximum...3,500 v.
	(*b*) when intended to be started up with the field windings separated by a field dividing switch.	5,000 v.
	(*c*) when intended to be started up with the fields on open circuited and without a field dividing switch.	5,000 v. when the excitation voltage is less than 275 v. 8,000 v. when the excitation voltage is equal to or exceeds 275 v.
4.	Exciter	Not less than that applied to the field windings of the machine to which it is connected, except when used with a synchronous machine intended to be started up from the alternating current side, in which case the test will be as given in Item 3(*a*) above.
5.	Secondary (rotor) windings of reversing induction motors not permanently short-circuited.	1,000 v. + four times the voltage between the slip rings at standstill on open circuit with full primary voltage applied to stator windings.

APPENDIX 4.

ELECTRIC GENERATORS AND MOTORS, INCLUDING EXCITERS, BALANCERS, BOOSTERS, AND THE MOTORS FOR DRIVING THEM, IN CONJUNCTION WITH ELECTRIC PROPELLING MACHINERY.

1. **Rating.**—The continuous rating is the load which can be carried on test for an unlimited period without exceeding the limits of temperature rise given in clause 3.

2. **Insulating Materials.**—Classes A and B materials are as defined in Appendix 2.

3. **Limits of Temperature Rise.**—The temperature rise measured by thermometer when tested under rated conditions is not to exceed the following limits, except that in tropical climates or where fixed in hot situations the temperature rise of the windings is not to exceed the limits specified in the **Rules for Electrical Equipment, Section 2, clause 1** and **Section 11, clauses 2** and **6** (*g*) and the **Rules for Electric Propelling Machinery, Section 6, clause 6** (*a*).

These temperature rises are suitable for machines working with a temperature of cooling air not exceeding 40° C.

The method of measurement applicable in any particular case is as specified in Appendix 3, **clause 3** (*c*) and (*d*).

Item.	Part of Machine.	Class A Material.		Class B Material.	
		By Thermometer method. 1.	By Resistance method. 2.	By Thermometer method. 3.	By Resistance method. 4.
1.	A.C. windings of stators or rotors.	72°F. (40°C.)	81°F. (45°C.)	90°F. (50°C.)	117°F. (65°C.)
2.	Field windings, stationary or rotating.	*	90°F. (50°C.)	*	108°F. (60°C.)
3.	Exciter field windings ...	72°F. (40°C.)	*	90°F. (50°C.)	*
4.	Low resistance field windings of more than one layer or compensating windings.	81°F. (45°C.)	*	99°F. (55°C.)	*
5.	Single layer field windings with exposed surface.	90°F. (50°C.)	117°F. (65°C.)	117°F. (65°C.)	117°F. (65°C.)
6.	Short-circuited windings, insulated.	90°F. (50°C.)	*	117°F. (65°C.)	*
7.	Windings of armatures having commutators.	72°F. (40°C.)	*	90°F. (50°C.)	*
8.	Commutators	81°F. (45°C.)		81°F. (45°C.)	
	Slip rings (open)	81°F. (45°C.)		81°F. (45°C.)	
	Slip rings (enclosed)	99°F. (55°C.)		99°F. (55°C.)	
9.	Short-circuited windings, un-insulated.	The temperature rise of these parts is in no case to reach such a value that there is risk of injury to any insulating or other material on adjacent parts.			
10.	Iron core and other parts not in contact with windings.				
11.	Iron core and other parts in contact with windings.	Same limits of temperature rise as permitted for adjacent parts as given in Cols. 1 and 3 (or Cols. 2 and 4) in case of item 2.			

*This method of measurement is not recognised in these cases.

4. Overloads and Excess Current and Torque.—Motors and generators are to be capable of carrying, without injury, the following sustained and momentary overloads after having attained the temperature rise corresponding to their rated load, the voltage being maintained at rated value and in the case of A.C. motors at rated frequency also.

Motors are to withstand the following overloads in torque :—

All sizes (including totally enclosed) { 25 per cent for two hours.
50 per cent for one minute.

GENERATORS, BALANCERS AND BOOSTERS are to withstand the following excess currents :—

25 per cent overload in current at full rated volts for two hours.

50 per cent overload in current for one minute, the voltage being maintained as near the rated value as possible, consistent with the maximum capacity of the prime mover. The exact value of the voltage is not important.

5. **Commutation.**—A D.C. machine is to work with fixed brush setting from no load to the momentary excess current or torque specified and is to work sparklessly and without injury to the surface of the commutator or brushes from no load to the rated load and without injurious sparking or injury to the commutator or brushes up to the momentary (one minute or less) excess current or torque specified.

The commutation test is to be applied at the conclusion of the temperature test.

6. **High Voltage (Dielectric) Tests.**—The high voltage test is to be applied only to new and completed machines in normal working condition with all its parts in place, at the makers' works, preferably at the conclusion of the temperature test. It will be applied between the windings and the frame with the core connected to the frame and to any windings not under test.

The full test voltage is to be maintained for one minute and is to be made with alternating voltage of any convenient frequency between 25 and 100 cycles per second.

Machine or Part.	Test Voltage.
1. Machines in general ...	1,000 v. + twice the rated voltage (with a minimum of 2,000 v.)
2. Field windings of synchronous generators when the excitation voltage does not exceed 750 v.	10 times the excitation voltage: Minimum...2,000 v. Maximum...3.500 v.
3. Exciter, booster or balancer used for excitation purposes.	Not less than that applied to the field windings of the machine to which it is connected, except when used with a synchronous machine intended to be started up from the alternating current side, in which case the test will be as given in Item 2 above.
4. Induction motor rotor windings not permanently short-circuited.	For non-reversing motors 1,000 v. + twice the maximum voltage which could be induced between the slip rings.

7. **Insulation Resistance.**—The insulation resistance in megohms when the high voltage test is applied is to be not less than

$$\frac{\text{rated volts}}{\text{1,000 v. + rated output in k.v.a. or B.H.P.}}$$

The insulation resistance is to be measured with a D.C. voltage of about 500.

8. **Performance Tests.**—Tests are to be carried out at the makers' works to ensure that the machine complies with the requirements in respect of limits of temperature rise, excess current and torque, commutation and high voltage tests.

The temperature test may be carried out at any convenient air temperature and no correction should be made in the observed temperature rise in those cases where the temperature of the cooling air during the test is different from

that expected in service. The temperature test for continuous rated machines is to continue until there is sufficient evidence that the temperature rise would not exceed the specified limits if the test were prolonged.

The temperature of cooling air is to be ascertained as prescribed in Appendix 3, **clause 3** (*f*).

71, Fenchurch Street, London, E.C.3.
21*st June*, 1934.

PERIODICAL SURVEYS OF ELECTRICAL EQUIPMENT.

1. On the occasions of vessels undergoing the special surveys Nos. 1, 2 and 3 prescribed in the Rules, and where a character is required for vessels not surveyed under construction, the electrical equipment is to be examined.

2.—(*a*) Where the electrical equipment is for lighting purposes only, the installations are to be generally examined and tested under working conditions.

(*b*) The fittings on all main and sub-distribution switchboards and boxes are to be examined to ensure that the circuits are not overfused.

(*c*) The electric cables are to be examined as far as practicable without dismantling any fixtures or casings unless such dismantling is deemed to be necessary as the result of tests and observation.

(*d*) A test is to be made on generators, cables, heaters, fittings, etc., and the insulation resistance is not to be less than 100,000 ohms.

3.—(*a*) Where the electric generators are also used for supplying power for driving auxiliary machinery, steering gear, windlass or refrigerating machinery, the prime movers are to be opened out for examination in accordance with the Rules for the survey of Machinery set forth on pages 22 to 25 of the Rules for Steel Ships.

(*b*) The generators and all motors driving essential auxiliary machinery are to be examined as far as practicable.

(*c*) All fittings on main and sub-distribution switchboards and boxes are to be examined to ensure that the circuits are not overfused.

(*d*) The electric cables are to be examined as far as practicable without dismantling any fixtures or casings unless such dismantling is deemed to be necessary as the result of tests and observation.

(*e*) A test is to be made on generators, motors, cables and other apparatus, heaters, fittings, etc., and the insulation resistance is not to be less than 100,000 ohms.

(*f*) All generators are to be run in turn or simultaneously ; all main switches and current breakers are to be operated, and all lamps, heaters, motors and other appliances run, though not necessarily under full load or simultaneously.

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